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THE CULTIVATION EXPERIMENT PLOTS AT BORBHETTA.

BY

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The cultivation experiment plots at Borbhetta occupy nineteen long narrow parallel strips of tea each 1/3 of an acre in area. Four different lots of tea are included and there is a " check plot " for each lot, so that no experimental plot is far removed from its check plot. Each different type of cultivation is applied only to a single plot so that there is no direct method of determining the degree of accuracy of the experiments.

The tea was planted in 1916 and 1917 and all treated alike up to the end of 1921. The yields for 1921 however do not in all cases give any indication of the relative initial yielding capacities of the plots because the number of infillings, still yielding nothing or little, was great in some plots and they were not evenly distributed.

In considering results it will be assumed that, had all the plots been treated similarly, they would have been giving similar yields in 1926. Differences in yields actually given in 1926 are ascribed to the effects of the different treatments.

The assumption is admittedly an important and far reaching one; but our experience with many other sets of similar plots justifies it within fair limits.

Such long narrow plots of tea, when mature, if not far removed from each other, do give roughly equal yields if under identical treatment. The difference between such similar neighbouring plots is rarely more than five per cent., although in a few cases it exceeds 10 per cent. Such great differences however only occur in the case of plots which contain considerable areas of " bad patches," the presence of which is easily apparent to the eye.

It may be therefore fairly assumed that any difference exceeding 10 per cent. is due to difference in treatment, while the results are generally more accurate than that.

The effect of " bad patches " is eliminated by dividing each big plot into five sub-plots. If any plot contains a bad patch of any extent, the yield of the sub-plot containing it will be greatly less than the mean yield of the whole big plot. The abnormal sub-plot then may be neglected in considering the average yield due to the particular treatment.

Corroborative evidence also may be gathered from consideration of the relative annual rise or fall in crop from any two plots, though this evidence must be used with care since the alternation of leaving unpruned and cutting on two year wood gave such great differences in crop for successive years. In the earlier years also the plots giving very small yield in 1921 on account of large numbers of infillings, all tended to even up in crop as the infillings became mature.

In all cases the " check plot " received what is considered to be the average " good cultivation " as usually practised, that is a deep hoe, and six light hoes.

PLOTS 91 to 96, 1916-PLANTED MATELLI PLOTS.

These plots were all very fairly even when the experiments started and in their case the error of the experiment is very small. They are therefore the easiest to discuss.

Table I shows the yields in 1926 of the individual sub-plots of plot Nos. 91 to 96 and their various treatments.

Table II shows the yields from the same whole big plots during each year from 1921 to 1926.

The tea was planted in 1916 and all was treated alike till 1922. Plot 96 was originally the best plot, because one of its nine lines borders a road with no drain near the tea. This line benefits very greatly from the absence of interfering roots from tea bushes on one side. In the case of all the other plots of this series, the outside lines have wide drains

within about 2 ft. of the collars of the bushes, which in consequence give less crop than the inside bushes. Apart from this "outside-line effect" which affects one of the plots and persists throughout the experiment, all the tea of these six plots was very fairly even when the experiment started.

In these cases the 1926 yields may be taken as very fair measurements of the effects of the differences in cultivation applied, and may be allowed to speak for themselves, but may be usefully checked by reference to Table II. Each plot will now be discussed separately.

PLOT NO. 91 (6 rounds forking). This in 1921 was giving practically the same yield as the check plot. When, in 1922, forking around the bushes was substituted for hoeing, the yield at once dropped significantly and continuously, till in 1925 the yield obtained was only 59 per cent. of that obtained by an equal number of light hoes.

The forking applied was such that all weeds were pulled out by the roots at each round.

Six rounds of such forking maintained a circle of always absolutely clean soil around the bushes leaving narrow strips of jungle between the bushes. On the check plot with six light hoes jungle becomes fairly thick, though not high, over the whole area, by the time the next round is due after 40 days' interval.

The difference in yield (5.4 maunds from forking against 9.1 maunds from hoeing in 1925) is consistent with the idea that there is some special virtue in keeping clean the soil between the bushes, as compared with the soil immediately around the collars. This idea is confirmed on other plots, where, as a result of cultivation only with buffalos, the tea is kept quite clean between the rows, while bad jungle grows around and through the bushes; yet the loss in crop is small compared to similar ordinarily hoed plots.

By the end of 1925, when the results from plot 92 also were considered, it appeared sufficiently well established that

six forkings gave about the same crop as two forkings. From the beginning of 1926 therefore plot 91 received the normal cultivation including six light hoes. The improvement by the end of the year is marked, and it is hoped will in time bring the crop from plot 91 up to that of the check plot, when plot 91 will be used for other experiments.

PLOT 92 (2 rounds forking).—Receives the same cultivation as plot 91 except that only two rounds of forking are given instead of six. Before the experiment started plot 92 was significantly better than the check plot and the loss in crop under this form of cultivation was large and progressive, but by 1925 seems to have settled down to an approach to a constant proportion of the check plot's yield, at which time there was little difference between the effects of two rounds of forking and six rounds of forking (plot 91).

By 1925 the cover from the bush was assisting greatly in suppressing jungle under it, and two forkings kept circles around the bushes just about as clean as six rounds of forking.

Jungle growing through the bushes is a nuisance interfering with plucking. It is therefore worth while to keep it out of the bushes, but there is little gain from increasing the amount of cultivation in the neighbourhood of the collar beyond that point.

PLOT NO. 93 (one ordinary deep hoe and six light hoes—CHECK PLOT)—gets average normal cultivation (one deep and six light hoes) and is used merely for purposes of comparison with the other forms of cultivation. It represents average good tea giving fair cover but allowing considerable jungle growth unless this is suppressed by some form of cultivation.

PLOT NO. 94 (18 inches deep hoe, six light hoes)—gets the same cultivation at the same times as plot 93 except that instead of the ordinary deep hoe to 7 or 8 inches deep, it gets a hoe every year to 18 inches deep.

This is put in with extreme care. Roots are damaged as little as possible, and the work is performed in such a way that

PLOT 95.

Deep hoed and forked in cold weather. After that sickled twice only.

the good top soil remains on top and is not buried. A very little subsoil has unavoidably been brought up every year so that the depth of dark top soil is now about eighteen inches.

With all this care, this excessively expensive work shows no sign of effecting any improvement in the tea.

From Table II it will be seen that up to the end of 1923 there was an apparent improvement amounting only to 3 per cent. which is not significant. Since 1923 there has been a continuous very small falling off in yield compared to the check plot. This decrease in yield is not yet great enough to be considered significant. It is however abundantly clear that this expensive operation is, at best, doing no good. There is no bad patch in Plot 94 which might reduce its yield abnormally, the yields from the sub-plots of plot 94 being in very fair agreement, as will be seen from Table I.

Plot 95 (Sickled twice). This plot is left quite clean after the cold weather cultivation, reduced tasks being given for the deep hoe in order to get all jungle buried. After this deep hoe the neighbourhood of the collar is completely cleaned by hand forking.

Its obvious suffering is therefore due only to the almost complete neglect of cultivation during the rains. It is sickled twice during the season in order that the pluckers may be enabled to pluck it; and receives no other attention. The sickling given is always quite complete, all jungle being cut to the ground right up to the collars of the bushes.

The very great and progressive loss of crop seen from Table II shows very forcibly the loss due to this extreme case of damage from the presence of jungle.

This plot in common with all the others received up to 12 light hoes annually before the experiment started. As soon as hoeing was stopped thatch began to invade from the drainsides, and before it is sickled this plot now looks like a thatch bari.

The extent of this invasion by thatch has not been uniform. A few patches still exist where only shallow-rooted, though

thick, grass grows. On these patches the tea is still relatively very good; while where thatch is really thick, the bushes hardly remain alive.

PLOT NO. 96 (3 light hoes, 3 rounds forking). This plot was, before the experiment started, giving 16 per cent. more crop than the check plot. This large difference was undoubtedly due to the increased yield from the line bordering the road, and this line still shows up as very markedly better than the inside lines. The outside lines of the other plots are alongside drains and suffer compared to inside lines. In spite of this advantage, the yield of this plot from having been 16 per cent. better than that of the check plot, has fallen progressively till in 1926 it was 8 per cent. worse. This drop is certainly significant.

The cultivation which this plot receives differs from that of the check plot only in that three rounds of forking round the bushes replace the last three light hoes.

The first three light hoes, which both receive, are sufficient to prevent invasion by thatch. By the end of the season the check plot has only a very little light jungle evenly distributed; while plot 96 is quite clean over wide circles around the bushes, with narrow strips of low-growing, shallow-rooted, but thick grass between the rows. It is clear that the presence of this jungle between the rows is sufficient to reduce crop significantly and progressively.

1917-PLANTED MATELLI PLOTS 87 to 90.

On these plots yields appeared in 1921 to be fairly even (see Table IV), but there were large numbers of bushes still not being plucked or yielding little. It was therefore decided to give them another year, before starting experiments.

In 1922 when all were still under the same cultivation, yields varied greatly. This variation is frequently observed when tea is cut low. The way in which it comes away is largely a matter of accident and there is no doubt that cutting back ought to be avoided in plots under experiment. It is a great pity that

PLOT 87.

Surface scraped only. Jungle on drain-side cut to show clean soil.

these plots were not given another year under the same treatment, particularly as the yields of the sub-plots in 1926 (Table III) show that the tea is very uneven.

The probability is that the tea was fairly even in 1921 and that the unevenness was produced by the cutting back of not very vigorous tea. Experience on other plots shows that after the cutting back, plots under the same treatment tend to revert to the same order of yield as given before the cutting, but that the effects of uneven " coming away " persist to some extent. Probably a fair index of the initial yielding capacity of these plots will be the sum of the yields in 1921 and 1922, but results from these plots up to the present must be regarded with a certain amount of doubt. As they are carried on, however, results will become more and more reliable.

Plot No. 87 (clean weeding).—In early 1923 it was attempted to keep this plot clean by hand weeding. This quite failed to keep down jungle efficiently, and a small relative drop in crop was obtained.

Later, Dutch hoes were tried. These, however, only uprooted the weeds, which, if rain fell, grew again, and the plot remained dirty with weeds.

In 1924, 1925, and 1926, the ordinary flat hoe has been used, once a month, to scrape all jungle into the middle of alternate lines of tea. The heap of jungle there largely rots and such as grows is scraped at the next monthly round into the middle of the next row previously left clean. The object of this work is to maintain soil free of weeds, without any stirring of the soil. This cultivation fulfils its object. From fairly early in 1925 practically clean soil has been maintained while the soil is stirred to a depth of less than one inch.

In spite of this lack of soil stirring it will be seen that while this plot yielded 13 per cent. less than the check plot in 1923, in 1926 it is giving 11 per cent. more than the check plot. (See Table IV.) It appears clear that as far as immediate crop

is concerned the suppression of jungle is of very great importance; and, in comparison, the stirring of the soil is a matter of small importance. Whether this plot will increase its lead over the hoed plot, or even maintain it, remains to be seen in the future. The stirring of the soil has been shown to be of benefit when organic matter, such as a green crop, is buried, and in tea cultivation, prunings are buried annually. There is considerable support, also, in general agriculture for the idea that the stirring of the soil, in the spring at least, is of value.

Any improvement from cultivation alone, also, must be made at the expense of the soil's reserve of food, unless this reserve is saved in some other way. It is possible that the avoidance of soil stirring may reduce the losses from washing out of soluble plant food, in which case the mere suppression of jungle may continue to prove effective. On the other hand the very effective suppression of jungle may lead to rapid soil exhaustion and deterioration of the tea unless manuring is increased. The future history of this plot will be watched with great interest.

Plot No. 88 (extra manure). In this plot the food denied to the tea bush by the presence of jungle due to lack of cultivation is partly made up for by the provision of soluble plant food as manure.

About the same amount of money is spent on this plot as on the check plot No. 89.

There is no need to bring any complicated arithmetic into service to show that the treatment of plot 89 (normal cultivation) has given better results than the spending of the money on manures while neglecting cultivation. (see Table III.) Under present conditions it is quite clear that five light hoes pay very much better than the same expenditure on manuring.

Labour however is becoming increasingly expensive and difficult to obtain, while manures are becoming cheaper.

Comparison of plot 88 with plot 95 is therefore of practical interest.

PLOT 88.

1 deep hoe, 1 light hoe in June and 1 round sickling in September but extra manure applied in June.
Photo taken 1 week after sickling in September.

PLOT 89. (CHECK PLOT.)

1 deep hoe. 1 round forking. 6 light hoes.

Left of Photo shows Plot 88, 3 months after its one light hoe in June.

In 1926 the check plot for plot 88 (plot 89) gave 9.55 mds., while the check plot for plot 95 (plot 93) gave 10.16 mds. There is not much difference between the 1916-planted and 1917-planted tea of the same Matelli jat, and therefore they may be fairly compared.

Plots 88 and 95 get practically the same cultivation. The only difference is that in June, when both are hidden under jungle, plot 88 gets a light hoe which amounts to little, if any, more than the sickling which plot 95 gets at the same time. Yet in 1926, plot 88 gives 65 per cent. of the yield of its check plot, while plot 95 gives only 36 per cent., little more than half the crop. This difference of about 3½ mds. of tea is obtained for the expenditure of Rs. 25/- on manuring. One does not find such a difference from light manuring on moderately well cultivated plots.

In this case also one does not obtain the increase at the expense of the soil, but because of an addition to the soil which improves it. Where cultivation is deficient, there will the greatest gain from manuring be found. Plot 88 indicates that the presence of jungle deprives the bush of natural food, which may be supplied as artificials.

Plot No. 89, Check Plot (one deep hoe and six light hoes). This plot is kept only for comparison with the other three plots of this series of experiments. It will be observed that one of the five sub-plots gives a yield far in excess of the mean of the whole plot. The other four contain no obvious bad patch of any extent. Sub-plot A is, apparently, on an exceptionally fertile piece of soil, so that the true relative yield due to this form of cultivation is probably rather lower than the mean of the five plots.

Incidentally it may be observed that the yield in 1926 from this 1917 planted tea (9.54 mds.) is not greatly different from that of the similarly treated plot 93 (10.15 mds.) planted in 1916. In 1921 the yields were, respectively, 5.34 and 6.22 mds. This illustrates the tendency of the plots to even up: plots which differed by 12½ per cent. in 1921, differ only by 6 per cent. in 1926, while the treatment has been identical for both.

PLOT NO. 90 (11 rounds forking). This may be considered to have been about equal to the check plot in yielding capacity when the experiment started. The maintenance of circles of absolutely clean soil by forking every month did not prevent a loss of crop roughly equal to the loss when about half or a quarter of the number of forkings were applied (plots 91 and 92).

By the end of 1924, this fact was considered sufficiently plain, and from the beginning of 1925 this plot received the same cultivation as the check plot, when the improvement was obvious, and will certainly become greater as the plot becomes freed of jungle.

Later on this plot will be used for other experiments. At present the recovery of poor tea by cultivation alone is well illustrated.

THE 1916-PLANTED SINGLO PLOTS.

Delicate light-leafed varieties like Singlo require a great deal of trouble and time to establish them at Borbhetta. On these plots the number of unproductive bushes in 1921 was great and varied greatly from plot to plot.

In this, the first tea planted at Borbhetta, great unevenness was produced by planting plot 78 first, when only good plants were used. The number of poor plants used became greater as the nursery was used up, so that plot 82 received a large number of poor plants which later had to be replaced.

The 1921 yield therefore gives no idea of the initial relative yielding capacities of the plots, since all the more poorly yielding plots tended to level up as bushes became mature.

This is made very plain by the behaviour of plot 81 which in spite of reduced cultivation made a relative improvement, compared to the check plot up to 1924. This is not so remarkable as it seems at first sight. At the end of 1921 all plots were absolutely clean having received unlimited cultivation to give them a fair start, and for a time there was not much more jungle on the plot receiving four light hoes (plot 81) than on the plot receiving six light hoes (plot 78).

The four light hoes applied to plot 81 are given at intervals of 60 days. Under this treatment they became increasingly infested with jungle, but only slowly, so that for some years the effect of increasing maturity of infillings more than counteracted the bad effect of the jungle.

The yields from these plots in the earlier years are therefore of little significance.

During 1925 and 1926 however the effect of cultivation had become the preponderating factor in influencing yield, and in considering the effects of different forms of cultivation, the yields in these years afford the most reliable means of comparison. Table V shows the yields of the individual sub-plots in 1926.

Plot No. 78, Check Plot (1 deep hoe and 6 light hoes). The yields of the five sub-plots are in fair agreement, so that the mean yield may be taken as a fair basis for comparison with the yields of the other big plots.

Plot No. 79 (no deep hoe). This plot receives the same cultivation as the check plot except that since 1922, the check plot has received an ordinary deep hoe (to about 7 or 8 inches deep), while plot 79 has on the same day received only an ordinary light hoe to perhaps as much as 3 inches deep. The deep hoe buries all prunings and buries all jungle out of sight. The light hoe leaves the prunings exposed, and also some of such jungle as there is, though neither of these plots has ever shown much jungle at the end of the season.

In 1926 the apparent loss of crop due to neglect of deep cultivation for five years is so small as possibly to be not significant. Reference to Table VI shows that from 1923 to 1925 the plot without a deep hoe was giving a slightly higher crop than the plot not getting a deep doe. The reduced crop in 1926 may therefore be significant, indicating that after five years without a deep hoe plot 79 has begun slightly to deteriorate.

If that is so, this plot should continue to drop in crop, and future years will make this point plain. In the meantime it is

quite clear that this plot has gone without a deep hoe for five years with very little loss of crop, if any.

Depth of cultivation, on this soil at any rate, is thus proved to be of relatively little importance.

PLOT No. 80, Trenching. This plot was trenched in 1922 in every other line, and in 1923 in the lines not trenched the previous year were also trenched; in each case to 18 ins. deep. In 1924, 1925 and 1926 it received exactly the same cultivation as the check plot.

It will be seen from Table V, that the yield obtained was 1½ mds. less than that from the check plot. Sub-plot A contains a bad patch, but even if this be neglected the mean of the other four sub-plots is still a maund less than from the check plots. This difference of about 10 per cent. may not be significant. It is possible that it may be due to initial difference in the fertility of the two plots.

It is however perfectly clear from these figures that the treatment received by plot 80, was certainly not better than that received by the check plot. That is, if the trenching in 1922 and 1923 ever did any good, the benefit did not last into 1926.

Referring to Table VI it will be seen that in 1921 this plot gave a crop very much below that of the check plot. Comparison is therefore more easily made with plot 79 which is immediately next to the trenched plot under consideration.

Since the evidence shows that this plot was not affected by the absence of a deep hoe, and otherwise had the same treatment as the check plot, plot 79 may be taken quite fairly as a comparison plot to determine the value of the trenching on plot 80.

In 1921, when both plots were under the same treatment plot 80 gave 90 per cent. of the yield of plot 79.

In succeeding years it gave the following percentages of the yields of plot 79.

1921.	1922.	1923.	1924.	1925.	1926.
90	91	87	94	89	90

It will be seen that the two plots have maintained practically the same relative positions. There is thus no evidence whatever that the trenching has produced any benefit. As has been explained, the general tendency in all the other plots has been for the originally poorer plots to even up towards the better plots in yield. The trenched plot has not shown this tendency, which might be taken as an indication that the trenching has done a little harm. This cannot be accepted as very definite evidence of actual harm from the trenching, but however the figures may be considered the evidence is quite conclusive that no benefit whatever has been gained from the expensive operation of trenching.

When records from gardens are studied, it is common to find that trenched areas do show some relative improvement compared to untreated areas, at least in the year immediately after the trenching. In such cases a good weight of green stuff of some sort has been put in the trenches, and from this manuring some gain is naturally expected.

In the case of these plots at Borbhetta, boga medeloa was cut from outside the tea, and the trenches filled before covering in with soil. The same weight of boga medeloa, however, was broadcast over the surface of all the other plots. All the plots, no doubt, gained from this manuring, but the manure was clearly at least as effective when merely deep-hoed or even light hoed in, as when buried in trenches.

The point is that when in garden practice benefit is apparent from trenching, the probability is that the benefit is purely from the manure applied and that in most cases the great expense of cutting 18 ins. trenches is merely waste of money, at best; while the danger of damage from cut roots makes trenching a very possible cause of definite harm. This opinion of course applies only to the general case where there is no " pan," layer of hard " kankar," or other mechanical obstruction in the soil. In such cases, there is no doubt, the obstruction must be broken; but it is strongly urged that labour should not be wasted on trenching, except where definite evidence of such obstruction has been obtained.

When a very heavy crop of Arhar, or boga medeloa has been allowed to grow, it is sometimes a matter of convenience to cut trenches in order to get the green stuff buried. In such cases, the trenches should not be more than 9 ins. deep. The manure will be more efficient at that depth, and the cost of making the 9 ins. trenches will be probably less than half that of 18 ins. trenches.

Plot No. 81 (four light hoes). Table V shows that this plot, in 1926, gave only 6.36 mds. of tea against 10.71 from the plot receiving six light hoes.

Sub-plot A contains a bad patch. If this be neglected, then four light hoes gives 6.84 mds. against 10.71 for six light hoes. There is no doubt whatever about the significance of this result.

Referring to Table VI, comparison is best made with reference to the adjoining plot No. 80, the treatment of which has been shown to have been, at best, no better than that of the check plot.

These two plots were not greatly different in 1921 before different treatment commenced.

Plot 81 has given the following percentages of the yield of plot 80.

1921.	1922.	1923.	1924.	1925.	1926.
96	87	94	95	77	69

It will be seen that, with the exception of 1922, the two plots maintained about the same relative position till the end of 1924. The drop in 1922, although the yields compared are very small, is probably significant. In this year the tea was cut to 8 ins. and provided little cover; so that, although the jungle was still of a good character, it became markedly more thick under reduced cultivation in the absence of cover from tea bushes.

It is rather remarkable that the effect of reduced cultivation, apart from 1922, did not make itself felt till after three years had elapsed. This is believed to be accounted for by the fact that both plots started very clean indeed, and that it took about three years for bad jungle to establish itself.

Plot 81.

Plot 82.

In 1925 and particularly in 1926, jungle, including a fair proportion of thatch, had become established and made its presence very definitely felt in greatly reduced crop, and in the poor appearance of the bushes.

PLOT NO. 82 (eleven light hoes). This plot in 1926 gave one maund more crop than plot 78 receiving only 6 light hoes. The yields of the 5 sub-plots are in very fair agreement, and this difference is probably quite significant.

Reference to Table VI shows that in 1921, when both were under the same treatment, plot 82 was giving only 69 per cent. of the yield of plot 78.

Apart from improvement due to treatment the differences would have become less in succeeding years, as the originally smaller-yielding plot would have tended to even up. It is however very improbable that if the two plots had been kept under the same treatment they would by 1926 have attained equality in yield.

The real difference due to treatment is therefore probably rather more than the 9 per cent. actually found in 1926. That the real difference is not much more than that, is indicated by the small relative increase made since 1923.

The very big jump made in 1922, when the tea was cut down, again indicates the special value of cultivation at a time when the tea bushes are giving no cover to assist in keeping down jungle.

A very big jump also was made in 1924 when the tea was cut to 12 ins. This great increase in crop, however, was not maintained in the following year when the tea was cut at 18 ins.

From 1926 onwards the tea being only top-pruned will cover the soil more and more completely, so that the difference in crop due to 11 light hoes as compared to 6 light hoes is not likely to increase greatly in coming years.

That a greater difference from five additional light hoes has not been found may be a matter for surprise in some quarters.

Throughout these experiments when any two plots are compared, it is very apparent that the factor which has the predominating effect on crop is the presence of jungle.

On plot 78 the 6 light hoes are distributed so that they come at 40 days' interval throughout the growing season. On plot 82 the eleven light hoes come once a month, or at about 30 days' interval.

On these two plots which started clean, and now carry tea which is giving considerable assistance in keeping down jungle, the difference in the amount of jungle growth is not great. Hence if the suppression of jungle is the main benefit of cultivation little difference in crop from good wide tea would be expected from increasing the number of hoes from six to eleven.

That plot No. 82 shows no greater yield after all the extra stirring of the soil which it has received indicates that the mere act of stirring the soil can produce very little benefit, if any.

THE 1917-PLANTED SINGLO PLOTS.

In the case of these plots no evidence is available with regard to the initial yielding capacity.

The bushes were collar pruned, as ready, from March 1919 onwards and were plucked as they became sufficiently strong. In 1921 only half the bushes were being plucked so that the yields for that year give no information, but by the end of the year, as all the weaker bushes had been unplucked, the tea was fairly even in appearance.

As the tea was cut down to 8 ins. yields in 1922 were very small and are therefore again of little value; particularly as, still, only 85 per cent. of the bushes were being plucked.

In 1922 the maximum difference from the check plot was 16 per cent. and it can be assumed that the general tendency would have been to even up.

Any great difference in yield in 1926, therefore, may be quite certainly considered to have been due to difference in treatment.

Since two of the treatments used are such as do produce very great differences, the results are worth quoting, although in the case of the pair of plots showing only a small difference, it would be certainly wrong to assume that this difference is entirely due to difference in treatment.

Plot No. 83 (3 light hoes and 8 rounds scraping). In 1923 this plot was used for a trial in the use of a wheeled hand-cultivator, which it was thought might prove of value in the cultivation of tea as it does of market garden crops which are planted in lines. It proved however quite ineffective in suppressing jungle growth, and reference to Table VIII shows that a loss in crop occurred under this form of cultivation.

From 1924 onwards this plot was used for a further trial of the scraping or "cheeling" already being tried on plot 87, but with a small variation. There is a very generally held view that stirring of the soil in the spring has a special value. In North-East India, certainly, there is at this time no fear of the damage by puddling the soil which might occur during the rains. This plot therefore is hoed during the spring, and cheeled during the rainy season.

It is hoped that, eventually, useful comparisons may be drawn between plots 82, 83 and 87.

All get the same cold weather cultivation in January, and all receive some other form of cultivation in the rains but—

Plot 82 is light hoed onced a month.

Plot 87 is "cheeled" once a month.

Plot 83 is light hoed in February, March, April, and cheeled in the remaining months of the year.

No direct comparison can be made yet, since the plots differ either in age or in variety of tea, but it is interesting to examine such evidence as is now available, by considering how each has already done with comparison to its own check plot.

It is probably best, in this case, to consider only the differences occurring in 1926, since by that time all plots had been under the treatment being discussed, for a year or two.

Plot.	Treatment.	Yield relative to check plot in 1926.
82	Light hoed 11 times	109
87	"Cheeled" 11 times	111
83	Light hoed 3 times Cheeled 8 times	159

These relative yields cannot be compared with any degree of accuracy, since the plots had been so different from their check plots in earlier years. From the difference of 2 per cent. between plots 82 and 87 certainly nothing can be inferred; but with respect to plot 83, the difference does appear too great to be due entirely to accident. The more complete suppression of jungle by cheeling instead of light hoeing probably gives it an advantage over plot 82; the stirring of the soil in the spring appears also to give an advantage over the mere scraping of the surface of the soil then practically clean; though the advantages spoken of are certainly nothing like so great as is made to appear by the figures above quoted. In later years, as the difference due to age of tea becomes of less effect, it should be possible to obtain a better comparison by considering the actual yields of the plots.

Plot No. 84 (deep digging with garden forks).—This cultivation is performed with the ordinary English garden digging-fork.

For the cold-weather cultivation the fork is pushed in by the foot perpendicularly to its full depth, and the clod is turned and broken, leaving the soil beautifully crumbly in appearance; and free of jungle.

During the rains this operation is repeated twice, but the fork being pushed in at an angle, the cultivation is more shallow, but still very complete and clean.

Plot 84.

Between these rounds of cultivation the jungle grows very thickly. In consequence, in spite of three very efficient stirrings of the soil, the tea grows very poorly indeed.

Table VII shows that the yields of the five sub-plots are consistently very low, and the miserable appearance of the whole plot convinces any planter who sees it that some adverse factor has been in operation. This can only be the jungle growth.

Reference to Table VIII shows that this plot was originally not as good as the check plot but that a very significant further loss of crop occurred in the very first year of this type of cultivation, since when the tea has become worse and worse.

This is a very common type of cultivation in the Darjeeling district. As jungle would not grow so fast there, it may not do so much harm as it does at Borbhetta. There can be, however, no doubt that the inefficiency of the methods of jungle suppression practised in the Darjeeling district is a very large factor in keeping tea crop down to a low level.

The application of methods of jungle suppression which will not increase the loss of soil by wash is undoubtedly the most important problem for the Darjeeling district.

Plot No. 85, Check Plot (1 deep and 6 light hoes, all with flat hoes).—Table VII shows that the respective yields of the five sub-plots of plot 85 are not consistent. Sub-plots C and D both give yields about 13 per cent. below that of the mean of the whole big plot. Both contain tea well below the average of the remainder of the sub-plot, but both contain definite bad patches of small extent only, so that one is hardly justified in rejecting them.

It is probable however that this plot is for the greater part on poorer soil than for example plot 86, or 83.

As will be obvious from the yields of only 6 or 7 maunds obtained nine years after planting, this is very backward tea, and yields may level up as it becomes more mature, particularly as the disturbing influence of low cutting will not again act for many years.

PLOT NO. 86.—This plot gets the same cultivation as the check plot (plot 85) except that the work is always done with fork hoes instead of with the usual flat hoes.

In 1926 it gave a yield 15 per cent. greater than that of the check plot.

Although it is probable that plot 86 enjoys better soil than plot 85, there are no other cases on the station where adjoining plots, of size and shape similar to these, differ by as much as 15 per cent. when under the same treatment. It seems probable, therefore, that some part of the difference of 15 per cent. may be due to difference in treatment.

It is very difficult to guess in what manner cultivation by forks should be better than cultivation by flat hoes. Perhaps here, too, benefit may be obtained from additional stirring of the soil in the spring.

This plot does not provide any indication that fork hoes should be used in practice, rather than flat hoes.

The only way to ensure that the cultivation is the same for all plots is to endeavour to get every round perfect; that is, every bit of the surface is cut and turned over. To do this with fork hoes requires considerably more time and energy than with flat hoes; and the work done on plot 86 with fork hoes could, in practice, only be done at a lower rate per day than the work with flat hoes on plot 85.

SUMMARY AND CONCLUSION.

It is not possible, or desirable, from consideration of these experiments, to suggest that any one of the forms of cultivation tried is the best. Even if the best system of cultivating a particular block of tea could be settled definitely, available labour supply would generally render the application of the system impossible; or if it were possible, it might very well prove to be more expensive than warranted by the increased return. The main problem, as it affects most gardens, is to make the most profitable use of such labour as is available.

For this purpose it is very necessary for us to understand as clearly as possible the general principle of the way in which cultivation acts, so that attention may be focussed on factors of maximum importance, and resources not wasted on matters of relatively small importance.

Cultivation operations may do good in several ways :—

(1) By suppressing weeds.

(2) By stirring the surface, which should increase the efficiency of the aeration of the surface and also may be useful mechanically in mixing with the soil either manures, or green stuff, or prunings, or even weeds.

(3) By extending the effects of this stirring to greater depths, and, incidentally, increasing the depth of "good, dark top soil."

1. All through the experiments which have been described the effect on crop of keeping down weeds stands out in the most marked manner. Excessive growth of weeds leads extremely rapidly to enormous losses of crop; while, on the other hand, increase in cultivation beyond the point at which jungle is practically suppressed leads to very small increase.

2. There is some evidence that the stirring of the soil in the spring may do some good; and there can, from first principles, be little doubt that manure should be mixed with the soil and not left lying on the surface.

Apart from these cases it appears clear that the stirring of the soil must be an extremely small factor in crop production compared to the suppression of jungle.

3. The evidence appears to be complete that within a period of five years there is no gain whatever from any form of deep cultivation on this particular soil. If deep cultivation can be neglected for five years with practically no loss of crop then whatever may happen in the future, deep cultivation is obviously a factor of much smaller importance than jungle suppression.

Whether deep cultivation would prove to be so small a factor in all tea soils cannot, of course, be decided from these experiments.

It is very generally held for example that even if a sandy soil like that of Borbhetta can do without deep cultivation, yet a clay soil must be stirred to greater depths. Extensive experiments on this subject were made by the U. S. Department of Agriculture.* The results of the investigation are worth quoting.

"Such beliefs (in the necessity for deep cultivation) apparently either overlook the luxuriant vegetation produced on land that has never known the tillage implements of man or assume that the roots of crop plants are essentially different in their relation to the soil than those of other plants or of the same plants growing wild."

"Sands and light sandy soils offer little resistance to the entry and downward passage of water. They are little changed and certainly not improved in this respect by cultivation. With the heavier clay soils in which penetration is slower and more difficult it would seem that there was more opportunity for improvement by a mechanical loosening. The result is not, however, what it might at first thought appear to be. The mechanical loosening that may be effected when such soils are dry enough to be loosened by tilling is of no consequence so long as the soil remains dry. When rains come and water enters the soil, it carries soil material with it in its downward passage through the loosened soil. The clay expands on becoming wet and the loosened and wetted area becomes an amorphous mass. On drying, the soil contracts. A part of the shrinkage is downward, and a part of it is lateral. The lateral shrinkage results in cracks that may open the soil as effectively as any tillage operation. Mathews* has shown that when allowed opportunity for free expansion, a soil when wet may occupy 2½ times the volume it did when dry."

" One cycle of wetting and drying overcomes the effect of " cultivation. As Mosier and Gustafson* say—

" ' The subsoil ran together as soon as it was wet and " ' became approximately as it was before.' "

" It is mistaking or failing to recognise the purpose of " plowing that leads to the belief that its efficiency increases with " its depth even though that depth be extended below all practical " limits of cost and effort. Plowing does not increase the water- " holding capacity of the soil, nor the area in which roots may " develop or from which the plants may obtain food. Plowing re- " moves from the surface either green or dry material that may " encumber it, provides a surface in which planting implements " may cover the seed, and removes or delays the competition of " weeds or plants other than those intended to grow, and in " some cases by loosening and roughening the immediate surface " checks the run-off of rain water. All these objects are accom- " plished as well by plowing to ordinary depths as by subsoiling, " dynamiting, or deep tilling by any other method. There is " little basis, therefore, for the expectation of increased yields " from these practices, and the results of the experiments show " that they have been generally ineffective."

" In their relative response to deep tillage there is no mark- " ed difference to be observed between crops."

" These conclusions are the result of extensive experiments " covering a wide range of crops, soils, and conditions in the Great " Plains. Experiments conducted in the Great Basin under semi- " arid conditions with the greater part of the precipitation occur- " ring in the winter; under humid conditions in the States of " Illinois, Pennsylvania, and Mississippi; under semiarid condi- " tions at San Antonio, Tex.; and under semiarid conditions on " the black soil of Southern Russia have all led to the same con- " clusion: that yield cannot be increased nor the effects of drouth " mitigated by tillage below the depth of ordinary plowing."

" The quite general popular brief in the efficiency of deep " tillage as a means of overcoming drouth or of increasing yields " has little foundation of fact, but is based on misconceptions and " lack of knowledge of the form and extent of the root systems of " plants and of the behaviour and movement of water in the soil."

Experience on nurseries shows that it is not quite true in North-East India, that " One cycle of wetting and drying over- " comes the effect of cultivation."

If a soil has been cultivated to a foot deep in say September or October before planting a nursery, then the disturbed soil is still found less compact than the undisturbed soil when the plants are lifted 18 months later, though no difference can be distinguished about 2½ years later. This point however is of little importance since the soil does not appear generally to be improved by this loosening.

From consideration of the evidence available it is perhaps still doubtful whether deep cultivation is of any value at all; but it is clear that its value is small compared to the enormously greater value of suppressing jungle. It is therefore urged that available resources should be devoted primarily to suppression of jungle, and that not until this object has been attained satisfactorily should labour be spent in such relatively unimportant operations as deep hoeing or trenching.

The ordinary deep hoe, of course, may be still be of value if it is found more efficient in suppressing jungle than the same amount of labour expended in light hoeing or on other forms of jungle suppression. At Borbhetta, certainly, one deep hoe is not as efficient as two light hoes, but on gardens which have been allowed to become very jungly during the growing season it may be found that the ordinary deep hoe (putting all jungle out of sight) has a greater efficiency than two light hoes, the completeness of which is not so easily checked.

At the present time the advice to suppress all jungle as completely as possible may be taken as a counsel of perfection, since

one's first thought is that this entails more light hoeing during the rains when so little labour is available.

What practical benefit, then arises from the deduction of these theoretical points?

Jungle may be suppressed by other means than hand labour, and the most efficient and easily provided means of suppressing jungle is shade. The planting of shade trees and cover crops will reduce the necessity for cultivation; but the most directly profitable method is to increase the cover provided by the tea bushes.

There are large numbers of areas scattered about the tea districts, where naturally rich soil has produced such fine growth of tea that the bushes cover the ground completely and nothing can grow under them. This is ideal tea, which requires the ideal cultivation—none at all. On poor or average tea, one cannot reach this ideal immediately; but, as this ideal is approached the necessity for cultivation will be more and more reduced. This of course means more manuring.

It has been shown that manuring will increase crop even from bushes growing among jungle. This crop comes from bushes of increased size, giving more cover. It has been shown also that correct manuring assists in replacing the coarser types of jungle by softer, shallower rooted, more easily suppressed jungle. The application of manures on a sufficiently large scale, accompanied by the concentration of available labour on whatever methods are found best to keep down jungle, is the general policy which is advised.

The use of shade trees will provide at least part of the manure very cheaply, and give also additional shade. Where a pan (or other obstruction to the passage of roots, water, and air) occurs, it must be broken; but it is waste of labour to trench or otherwise deeply cultivate all areas indiscriminately in case they may be panned. Roots will turn off horizontally from a pan, and this evidence should be looked for, before expending money and

labour on probably unnecessary trenching. Where plenty of labour is available crop will be produced more cheaply by increasing the rate of availability of the soil's natural stores of food by cultivation, than by adding manures. Such good cultivation, particularly on soils only partly occupied by tea and shade trees, must increase the rate of deterioration of the soil, and manuring will become, eventually, all the more necessary. Deterioration however would be very slow on soil fully occupied by bushes and shade trees, particularly if the soil were not stirred.

Clean soil appears to be the ideal on flat land.

On slopes, absolutely clean soil would greatly increase the loss of soil by wash; unless adequate protection is provided by such means as terraces, contour bunds, contour hedges, and systems of drainage which lead the overflow into safe channels. On unprotected slopes, the ideal would be the covering of the soil with a low-growing shallow-rooted leguminous plant, which, although it must reduce the available food supply would do so far less than the common tea garden weeds. Pending the establishment of such a plant, the practice now advised in Java and other tea districts appears the soundest which can be advised. That is, selective weeding. This means the eradication first of the arch-enemy thatch, and of other such coarse grasses as are noticed to be strongly growing and harmful; while plants such as Ageratum and dhoob-grass are left to hold up the soil.

With regard to thatch, some use may be made of the fact that it does not flourish in acid soils while tea does. The strongest thatch is found in soils of deficient acidity, which encourage the thatch, and discourage the tea. On such places the use of sulphate of ammonia not only strengthens the tea to smother the thatch, and discourages the thatch, but favours the growth of shallow-rooted plants to occupy the soil and retard reinvasion by thatch. As an extreme case, the application of a large dose of sulphur, on a small plot at Tocklai, has rendered the soil so acid, that no plant except tea will grow upon it.

TABLE I.

Yields in 1926 from 1916-planted Matelli Plots.

	Plot 91.	Plot 92	Plot 93. Check Plot.	Plot 94.	Plot 95.	Plot 96.
Cold weather cultivation	1 deep hoe 1 round forking	1 deep hoe 1 round forking	1 deep hoe (7″—8″) 1 round forking	1 very deep hoe (18″) 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking
Rains cultivation	6 rounds forking (till end of 1925 after which, same as check plot).	2 rounds forking	6 light hoes	6 light hoes	Sickled twice	3 light hoes 3 round forking
Yield of sub-plots in mds. pucca tea per acre :—						
A	6·94	5·23	10·90	9·82	4·35	9·04
B	6·24	6·27	10·65	9·03	3·65	9·57
C	7·91	7·40	8·64	9·95	3·13	8·73
D	6·09	5·89	10·32	9·77	3·49	9·80
E	7·68	5·42	10·29	10·83	3·77	9·66
Mean yield 1926	6·97	6·04	10·16	9·88	3·68	9·36

TABLE II.

Annual yields from 1916-planted Matelli Plots.

Pruning inches from ground		1921 Unpruned	1922 Cut to 8″	1923 Unpruned	1924 Cut to 12″	1925 Cut to 18″	1926 Cut to 19″	Cultivation in 1922 and following years.
Plot No. 91	Mds. tea per acre	6·32	2·95	9·99	4·63	5·36	6·96	deep hoe, 1 round forking } January-February. 6 round forking, up to 1925. } during cultivation as for plot 93 in 1926. } season.
	Yield relative to plot 93 as 100	101	88	80	75	59	69	
Plot No. 92	Mds. tea per acre	6·95	3·03	10·49	4·37	5·16	6·04	deep hoe, 1 round forking } January-February. 2 rounds forking during season.
	Yield relative to plot 93 as 100	111	91	76	71	57	59	
Plot No. 93	Mds. tea per acre	6·22	3·33	13·92	6·13	9·09	10·15	deep hoe (7″ to 8″), 1 round forking } January-February. 6 light hoes.
	Yield relative to plot 93 as 100	100	100	100	100	100	100	
Plot No. 94	Mds. tea per acre	6·41	3·85	14·76	6·11	9·02	9·86	very deep hoe (18″), 1 round forking } January-February. 6 light hoes.
	Yield relative to plot 93 as 100	103	105	106	100	99	97	
Plot No. 95	Mds. tea per acre	6·47	2·57	8·48	3·34	3·67	3·67	deep hoe, 1 round forking } January-February. sickled twice (June and September).
	Yield relative to plot 93 as 100	104	77	61	54	40	36	
Plot No. 96	Mds. tea per acre	7·22	3·99	14·28	7·11	8·84	9·34	deep hoe, 1 round forking } January-February. 3 light hoes. 3 rounds forking.
	Yield relative to plot 93 as 100	116	110	103	114	97	92	

TABLE III.

Yield in 1926 for 1917-planted Matelli Plots.

	Plot 87	Plot 88	Check Plot Plot 89	Plot 90
Cold weather cultivation	1 deep hoe 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking
Rains cultivation	scraped (cheeled) 11 times	1 light hoe in June, following application of extra manure	6 light hoes	*1923 to 1924* 11 rounds forking around bushes. *1925 and 1926* 6 light hoes.
Yields of sub-plots in Mds. pucca tea per acre :				
A	10·18	7·05	12·64	9·33
B	9·07	5·57	9·92	8·82
C	11·78	6·83	8·82	7·77
D	11·53	5·53	7·94	7·08
E	11·42	5·81	8·39	7·75
Mean	10·60	6·16	9·54	8·15

TABLE IV.

Annual yields from 1917-planted Matelli Plots.

Years		1921	1922	Probable initial relative yielding capacity.	1923	1924	1925	1926	Rains cultivation in 1923 and following years.
Pruning (from ground)		Unpruned	Cut to 8″		Unpruned	Cut to 12″	Cut to 18″	Cut to 19″	
Plot No. 87	Mds. tea per acre	5·36	2·42	7·78	12·10	4·89	8·00	10·60	Various attempts at clean weeding.
	Yield relative to plot 89 as 100	100	81	94	92	87	95	111	From 1924 onwards, jungle scraped off with hoes once a month.
Plot No. 88	Mds. tea per acre	5·04	2·52	7·56	11·46	4·02	5·55	6·16	1 light hoe in June after broadcasting manure to value of 5 light hoes (Rs. 25) Sickled in September.
	Yield relative to plot 89 as 100	94	84	91	87	72	65	65	
Plot No. 89	Mds. tea per acre	5·34	2·97	8·31	13·19	5·59	8·47	9·55	Check plot.
	Yield relative to plot 89 as 100	100	100	100	100	100	100	100	6 light hoes.
Plot No. 90	Mds. tea per acre	5·68	2·80	8·48	11·31	4·11	(6·75)	(8·15)	11 rounds forking round bushes till end 1924.
	Yield relative to plot 89 as 100	106	93	102	86	73	80	85	Same as check plot in 1925 and 1926.

TABLE V.

Yields in 1926 from 1916-planted Singlo Plots

		Plot 78 check plot.	Plot 79.	Plot 80.	Plot 81.	Plot 82.
Cold weather cultivation.		1 deep hoe 1 round forking	1 light hoe 1 round forking	1922 & 1923 trenched 1 round forking 1923 to 1926 1 deep hoe 1 round forking.	1 deep hoe 1 round forking.	1 deep hoe 1 round forking.
Rains cultivation		6 light hoes	6 light hoes	6 light hoes	4 light hoes	11 light hoes
Yields of sub-plots in nds. pucca tea per acre,	A	10·70	11·00	7·76*	4·41*	11·71
	B	10·23	9·27	9·12	6·28	12·43
	C	11·05	10·44	9·61	6·99	11·33
	D	11·64	11·43	10·61	7·43	11·82
	E	9·93	9·73	9·24	6·68	11·21
	Mean =	10·71	10·37	9·27	6·36	11·70
or neglecting bad patches marked,*	Mean =	10·71	10·37	9·65	6·84	11·70

TABLE VI.

Annual yields from 1916-planted Singlo Plots.

Pruning (from ground)		1921	1922	1923	1924	1925	1926	Cultivation from 1925 onwards.
		Unpruned	Cut to 8″	Unpruned	Cut to 12″	Cut to 18″	Cut to 19″	
Plot No. 78	Mds tea per acre	7·54	3·44	11·31	3·60	7·31	10·71	*Check Plot.* 1 deep hoe. 1 round forking. 6 light hoes.
	Yield relative to plot 78 as 100	100	100	100	100	100	100	
Plot No. 79	Mds tea per acre	6·67	3·26	11·62	3·79	7·35	10·37	*No deep hoe.* 1 light hoe. 1 round forking. 6 light hoes.
	Yield relative to plot 78 as 100	87	95	103	105	103	97	
Plot No. 80	Mds. tea per acre	6·03	2·97	10·47	3·56	6·54	9·27	*Trenching.* *1922 & 1923.* trenched alternate lines. 1 round forking. *1924 to 1926.* 1 deep hoe. 1 round forking. *All years.* 6 light hoes, in rains.
	Yield relative to plot 78 as 100	79	85	93	99	88	87	
Plot No. 81	Mds. tea per acre	5·79	2·59	9·84	3·38	5·00	6·36	*Reduced cultivation.* 1 deep hoe. 1 round forking. 4 light hoes.
	Yield relative to plot 78 as 100	76	71	87	94	68	59	
Plot No. 82	Mds. tea per acre	5·30	3·10	11·72	4·80	7·54	11·70	*Increased cultivation.* 1 deep hoe. 1 round forking. 11 light hoes.
	Yield relative to plot 78 as 100	69	92	104	134	103	109	

TABLE VII

Yields in 1926 from 1917-planted Singlo Plots.

	Plot 83.	Plot 84.	Plot 85 Check plot.	Plot 86.
Cold weather cultivation	1 deep hoe 1 round forking	1 deep fork (1 ft.) 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking
Rains cultivation	3 light hoes (Feb., March, April). 8 rounds cheeling	2 light forks (6 to 8 inches) all work with English long-handled garden fork	6 light hoes all work with flat hoes	6 light hoes all work with fork hoes
Yields of sub-plots in mds. pucca tea per acre				
A	11·47	3·03	7·22	7·86
B	8·92	2·24	6·00	6·30
C	8·74	2·22	5·39	7·25
D	9·27	2·46	5·23	6·41
E	10·14	3·47	6·85	7·44
Mean	9·71	2·68	6·14	7·05

TABLE VIII.

Annual yields from 1917-planted Singlo Plots.

Pruning inches from ground		1922. Cut to 8″	1923. Unpruned	1924. Cut to 12″	1925. Cut to 18″	1926. Cut to 19″	Cultivation in 1923 and following years.
Plot No. 83	Mds. tea per acre	1·66	6·54	2·45	5·23	9·71	*1923* hand cultivator. *1924 and following years.* 3 light hoes. 8 rounds cheeling.
	Yield relative to plot 85 as 100	96	89	109	113	159	
Plot No. 84	Mds. tea per acre	1·46	4·08	1·39	2·46	2·69	1 deep digging and 2 shallower.
	Yields relative to plot 85 as 100	84	56	61	54	44	diggings with English garden forks.
Plot No. 85	Mds. tea per acre	1·74	7·28	2·26	4·55	6·10	1 deep hoe 6 light hoes all with flat hoes. Check Plot.
	Yield relative to plot 85 as 100	100	100	100	100	100	
Plot No. 86	Mds. tea per acre	1·79	7·12	2·41	5·25	7·02	1 deep hoe 6 light hoes
	Yield relative to plot 85 as 100	103	98	107	115	115	all with fork hoes.

PHYSICAL FEATURES
OF
THE TEA DISTRICTS
OF
DARJEELING.

A MAP OF THE TEA DISTRICT OF DARJEELING SHOWING THE PHYSICAL CHARACTERISTICS OF THE DISTRICT.

BY

E. A. ANDREWS.

The map reproduced in this issue of the Journal is one which the writer prepared, at considerable cost in time and labour, in order to acquire a proper appreciation of the physical characteristics of the Darjeeling district, the relationship of the different valleys to the district and to each other, and the difference in conditions in different parts of the area, more particularly during the monsoon period.

It has since been under frequent reference in discussing matters connected with tea in Darjeeling with planters and other interested people, and it has been found of great value in giving them a grasp of these characteristics and peculiarities of the district. It is very difficult, in a mountainous locality such as Darjeeling, more especially when vision is almost continually obscured in one, or all directions, by cloud or mist, to obtain any proper idea of the difference in conditions in different places, or even of the lie of the land. There are excellent Government maps, but they, again, are difficult to interpret without some knowledge of map reading, and even planters who have spent several years in Darjeeling have stated that this map has given them an understanding of the district they did not possess before. The map has been filed away for some time, with the idea of publication in a subsequent work on tea, but so many have suggested that it would be of value to many people to have the map for reference in the meantime that it has been decided to publish it in this Journal, for the benefit of such as may find it instructive and useful.

The map was prepared from the Government Survey Maps No. 78 $\frac{A}{4 \& 8}$ and No. 78 $\frac{B}{1 \& 5}$. These are on the scale of 1 inch to a mile. In reducing, the originals were carefully

divided into squares of 1 centimetre side, and a sheet of drawing paper carefully squared with squares of 1/10 inch side. Taking 1 centimetre as equivalent to 0.3937 inch, this reduces the scale to 0.2539 inch to 1 mile—which may be taken as ¼ inch to 1 mile.

In preparing the map the contours were carefully sketched in, square by square, and the course of the rivers was sketched in similarly, so that the map may be regarded as reasonably accurate. The map shows 1,000-foot contours, which can be identified from the scale of colours given at the side. It also shows the boundaries of the various geological series of rocks in the district. These were sketched in from the geological map published by the Geological Survey of India in the Memoir (vol. XI, pt. 1) by F. R. Mallet, "On the Geology of the Darjeeling District and the Western Duars." Thus, when the position of any garden has been located on the map, both its topographical and geological characteristics are indicated.

It will be observed that the whole of the Darjeeling district is not represented, but only the Western half, this being the area in which all the tea gardens (except one or two like Fagu and Kumai, which have their outlet into the Western Duars) are situated. This area forms a block which, omitting the high lands in the North-West corner, may be regarded as roughly 20 miles square, though owing to the mountainous nature of the district the actual area comprised within that square is increased. It is bounded on the North by the Ramman and Great Rangit rivers; on the East by the Teesta river; on the West by the hills of the Singalila range to the North and the Mechi river to the South, and on the South by the plains of the Terai. It will be noticed that the boundary between the plains of the Terai and the hills is a sharp one, and the hills, in fact, rise abruptly from the plains. The great Himalayan range is commonly divided into three zones —first, the great range of snowy peaks which form the axis of the chain; second, the Lower or outer Himalayas, a broad belt of lower mountains south of the snows; and the third, the sub-Himalayan zone, a belt of comparatively low hills forming ridges

and spurs either projecting from the Lower Himalayas or separated from them by the level valleys known as "Duns." The sub-Himalayan zone is missing in this district, and the tea district of Darjeeling is in the Lower Himalayan zone, which rises abruptly from the plains in this region.

The configuration of the district is clearly shown in the map. The Singalila range throws out a ridge, at an elevation of 7,000 to 8,000 feet which, lying in an east and westerly direction, extends from Simana-basti on the west to Ghum on the east. To the north of this ridge the land descends to the Great Rangit. To the south of the ridge the land descends to the plains. From near Ghoom three other hill ranges radiate. To the south, the Senchal-Mahaldiram ridge extends towards Kurseong, at an elevation of from about 8,000 feet towards Ghoom to 7,000 feet at the south, where it forks, one spur passing west of south, the other south-east and then east. Between the spurs forming this fork is the valley of the Mahanadi river, opening on to the plains to the south. To the west of the main Senchal-Mahaldiram ridge is the valley of the Balasun, also opening to the plains to the south, and bounded, still further west by a ridge passing south from the Singalila range, on the other side of which is the Mechi river. Smaller spurs thrown off by the Simana-Ghoom range and the Senchal-Mahaldiram range, delimit the tributary valleys of the Balasun—the Rungbong valley, the Nagri valley, the Sonada valley, etc.

From the main Senchal ridge another range, the Tukdah range, branches off, a little east of Ghum, and takes a north-easterly direction to the junction of the Great Rangit and Teesta rivers, ranging in elevation from over 7,000 feet near Ghum to less than 1,000 feet to the north-east. Subsidiary spurs from this range and the Senchal-Mahaldiram range divide the area between into the valleys of the Rangu, Rangjo, and Reaing rivers, all of which flow east into the Teesta river, the valley of which is a gorge passing almost directly north and south to open on the plain of the Terai.

A further range, the Darjeeling-Jalapahar range, extends northward from Ghoom at an elevation of between 7,000 and 8,000 feet to Darjeeling, where it forks and gives off two spurs, the Lebong spur and the Tukvar spur. Between this range and the Tukdah range lies the valley of the Rangu river, and to the west, between the Darjeeling range and the spurs of the Singalila ridge, the valley of the Little Rangit, both rivers flowing in a north-easterly direction into the Great Rangit.

The whole area may thus be regarded as composed of seven narrow river-valleys, radiating from a watershed in the centre of the district. Opening to the south are the valleys of the Balasun and Mahanadi; opening eastward are the valleys of the Rangu and the Little Rangit.

Thus, speaking generally, elevations decrease in all directions from the centre of the district, the valleys widen, and the hill slopes become less precipitous. The elevation of the centre of the district is, for the most part, round about 7,000 feet rising to 8,000 in places. At the boundaries on the north, east, and south the elevation is below 1,000 feet above sea level.

The tea gardens of Darjeeling are situated on the flanks of the various river valleys, and on the spurs projecting from the ridges between the valleys, at all elevations from the lowest to about 6,000 feet, though there is a little tea above this elevation. There is, however, no tea West of the Little Rangit river, and the whole of the Reaing valley, and the south bank of the Rangjo river, is given over to the Cinchona reserve.

It is easy to see, from a glance at this map, that conditions, during the monsoon (which is the growing season) may be very different in, say, the Balasun, Rangnu, and Rangu valleys, and that an adequate realisation of the position of any one tea garden, with reference to the whole complex, is essential to a proper appreciation of the special problems connected with the cultivation of tea on that estate.

The moisture-laden winds prevalent in the monsoon enter the district from the south. It therefore follows that the valleys

of the Balasun and Mahanadi, which open to the south, are fully exposed to them, whereas the winds, before reaching the valleys of the Rangjo and the Rangu, have been checked to a certain degree by the intervening ranges, and lost a good deal of their moisture, while after passing over the main watershed to enter the valleys of the Rangu and the Little Rangit they have lost even more. This is shown distinctly by the rainfall figures. For instance, the average rainfall, for 37 years, at Kurseong, situated in an exposed situation on the Senchal-Mahaldiram range, is 161.26 inches; the average rainfall, for 41 years, at Gielle in the Rangu valley, is 117.3 inches while the average rainfall at Ging, in the Rangnu valley, for 18 years, is 84.05 inches. These differences might possibly be intensified were it not for the fact that part of the monsoon wind also reaches the Rangu and the Rangu valleys by way of the Teesta gorge.

Not only is the rainfall controlled by the valley in which the estate is situated, but also by the position occupied by an estate in the valley. For instance, the head of the Rangnu valley, to reach which the monsoon winds have first to pass over the Ghoom Jalapahar range, affords an excellent example of the effect of situation on rainfall. Mineral Spring is on the lee-side of the valley directly beneath the crest of the range. The air passing over the ridge expands and descends on entering the valley, and is compressed and deflected upwards again on striking the Lebong spur on the other side of the river. In consequence, it is found that the average rainfall at Mineral Spring, for the five years, 1919 to 1923, was only 78.8 inches, while at Bannockburn, directly opposite, the average for the same period was 86.3. Beyond Bannockburn, to the north and further away from the Ghoom ridge, the rainfall gradually decreases, and at Ging the average for the same period is 77.8 inches.

Another feature which this map helps one to appreciate is the liability of different estates, or parts of estates, to mist. The mist line ranges between 4,000 and 4,500 feet and can distinctly be traced by following the contours.

The map also shows the range of the different geological formations. The whole of the centre and west of the district is situated on the Darjeeling gneiss. The lower ends of the valleys, and of the spurs between them, are situated on a series of rocks consisting largely of shales and slates, and known as the Daling Series. Across the centre of the Mahanadi valley is an outcrop of a mass of shales and sandstones known as the Damuda series, while gardens on the spurs to the extreme south are situated on a group of soft massive sandstones with pebbly formations often containing a considerable amount of lime, known as the Nahun Group. These differences in rock formation are accompanied by corresponding differences in soil composition.

Altogether, the Darjeeling district is unique in tea in North-East India, in the variety of problems it presents in the cultivation of tea, and it is hoped that this map, and the accompanying short description, may help others in co-ordinating and correlating their observations, as it has helped the writer.

VEGETABLE PARASITES OF THE TEA PLANT

(*continued.*)

The Blights.

By A. C. Tunstall.

Exobasidium vexans, Massee.

Blister blight, White Blister.

Refs.—

Watt and Mann, " The Pests and Blights of the Tea Plant," 2nd. ed., p. 387.

McRae, " The Outbreak of Blister Blight on Tea in the Darjeeling District in 1908-1909, Pamphlet No. 32, Indian Tea Association."

Butler, " Fungi and Disease in Plants," p. 422.

Petch, " Diseases of the Tea Bush," p. 51.

Indian Tea Association, Scientific Department, Quarterly Journals 1915, Part I, p. 15; 1921, Part IV, p. 209; 1922, Part II, p. 35 and 1927, Part I, p. 20.

Found in Upper Assam, Darjeeling and in a few gardens in the Dooars and the North of Surma Valley.

History.—Blister blight was first described by Mr. S. E. Peal in 1868. He stated that he had known it ten years before. It is probable that it is indigenous to Upper Assam. All sorts of theories were advanced to account for the disease. The most popular seemed to be that the sun caused the blisters. Unfortunately for this theory the disease thrives best in shady places. In 1895 however Mr. G. Massee of Kew definitely ascertained that the cause of the disease was a fungus which he named *Exobasidium vexans.* In regard to its distribution Watt and Mann made the following statement—" So far as we have

been able to observe, this blight is, and has hitherto been, exclusively confined to Upper Assam. It has never been definitely reported below the Jorhat District on the South and the North Lakhimpur District on the North Bank. It has never visited either Cachar, Sylhet, Darjeeling or the Dooars."

In 1907, however, the blight suddenly appeared in the Rungbong Valley of the Darjeeling District. In 1908 it was found all over that district except in the Teesta Valley which it reached in 1909. About the same time it appeared on a garden in Bhutan situated at a great distance from other infected tea gardens and not directly connected with any. It was also found on a number of other more or less isolated gardens, *e.g.*, Kerkeria in Mangaldai and Fagu in the Dooars. The infected gardens at the foot of the Hymalayas are widely separated but they had one point in common, they were each particularly exposed to winds from gorges directly connected with the higher ranges. In 1925 the disease was observed near Nigriting. In the same year it was also found at Numalighar a few miles further South. Late in 1926 the disease appeared on a few gardens in the Surma Valley. The first specimens were received from Mr. Gupta, Manager of Sabazpore Tea Estate. At first the disease only attacked the gardens in North Cachar and a few gardens on slopes facing East and North-East of the Longai and Hailakandy Valleys. By March the disease had extended to the other side of these valleys and southwards to the Chargola Valley. By May 1927 the disease was to be found scattered over the whole of the northern end of the Surma Valley. The attack was not serious and no time was lost in dealing with it. By the end of July the disease had apparently disappeared. It remains to be seen whether it will reappear in the next cold weather.

Description.—Blister blight usually attacks the young leaves but is also found on succulent green stems of the tea plant. The blight at first appears as round, translucent, pale yellow, sometimes pink, spots on the leaf. As the disease progresses these spots enlarge into white or pinkish convex warts, mostly on the

under-surface of the leaf. The opposite surface of the leaf is pale green, yellow or pink, with a concave depression. At a later stage these white convex warts shrink and darken into deep brown, almost black spots. These dried up spots sometimes crack and fall out, leaving round holes in the leaf. When several spots coalesce, or the disease attacks the mid-rib, the leaf becomes curled and distorted.

Examined by a pocket lens, the white surface of the spot is seen to be covered by woolly thread-like outgrowths having a powdery appearance. These are the fructifications of the fungus. A cross section of a spot will show under the microscope, that the cells in the convex part of the leaf have been pushed aside by the fungus, thus causing one side of the leaf to bulge. The cells of the diseased patch of the leaf contain less chlorophyll than the normal, and in some cases the cell contents are changed into reddish coloured substances. The filaments are mostly collected between the cells. Some of them, very much more fragile than the rest, enter the cells themselves. These filaments are divided by many cross walls.

The fungus can be grown in pure culture, but is very susceptible to high temperatures. The isolated spores of both kinds only survive a few hours, and no resting stage of any kind seems to be produced. It is very difficult to get the live blister blight fungus from Darjeeling to Assam. Blister on diseased leaves sent in the ordinary way through the post rarely survives the journey. The infection of the leaf takes place through the stomata, the little mouth-like openings on the under-surface of the leaf. The fungus is purely local, and each blister is the result of a separate infection. The fungus mycelium does not spread beyond the edge of the blister into the other tissues of the leaf or stem. The fungus, under ordinary circumstances, takes 10 or 11 days to develop from the time of infection to the formation of spores. It then continues to produce spores for seven or eight days when the disease dies away. This period is variable according to temperature. At high temperatures 80°-90° F, the fungus does not cause any appreciable damage.

At low temperatures 40°-50° F the development is very slow. The optimum for the fungus seems to be between 65°-75°F. The fructifications of the fungus arise from bundles of mycelium which push their way through the skin, forming a continuous layer of vertical filaments or hyphæ over the surface of the leaf. The end of each hypha or filament swells like a club. Some of these remain so, without undergoing any further change. In others the swollen end is separated from the rest by a wall, giving rise to a spore, known as conidiospore. This is the commoner form of fructification. In the early part of the season, and occasionally at other times, other filaments grow out 2 to 5 little horns called sterigmata. At the end of each of these horns a spore is formed. The filament with the horns and spores is called a basidium, and this kind of spore is called a basidiospore. This method of fructification is characteristic of the group of fungi to which Blister blight belongs. Other members of this group have special protecting devices, *e.g.*, the pores of the bracket fungi, or the gills of the mushrooms, etc. In the case of Blister blight the basidia are formed outside, on the surface, hence the name *Exobasidium*. The reason for the other part of the name—*vexans*—is obvious to planters. There are species of *Exobasidium* present all over the Rhododendron forests to the North-East of Darjeeling.

The conidiospores are usually single cells but occasionally are uniseptate.

The basidiospores are sausage-shaped, hyaline bodies. The size and shape vary considerably.

Blister blight not only attacks the leaves and shoots but also the young seeds. These are aborted and sometimes swell up to the size of a walnut. The fruits are not commonly attacked because they are not usually present at the time of the year when the disease is most prevalent. The fruits attacked by the disease never mature.

Depredations.—A bad attack of this disease, once seen, is never forgotten. The whole of the succulent growth may be

destroyed. The rapidity with which it spreads is almost incredible. In a single night a whole hill side may become white. The more succulent the leaf the more susceptible it is to attack. It naturally follows therefore that the young growth on heavy pruned tea is particularly liable to damage. In the plains gardens the virulence of the disease varies from year to year but in the hill districts there is little variation. The cause of the variation has been traced to climatic conditions. It has been found that the fungus is particularly susceptible to the influence of temperature. High temperatures are fatal to the fungus and its spores. The normal temperatures of the air 80°-90°F in the plains districts during the rains are sufficient to kill the fungus. It has been found that the fungus in specimens of Blister blight sent by post from Darjeeling to Tocklai during the rains is invariably dead on arrival. It is only capable of survival in the plains during the hotter months of the year in cool shady places.

Remedies.—If the disease has been allowed to become prevalent on a garden it is useless to attempt to eradicate it until climatic conditions are unfavourable to the fungus. The most that can be done is to protect the young growth on cut back or heavy pruned bushes and young tea by spraying at frequent intervals with a fungicide, *e.g.*, Lime sulphur. This will prevent permanent damage to the plants concerned. When the weather becomes hotter the disease will die out in the plains districts in all places exposed to the sun and there is a chance of eradicating the disease by the careful removal of all diseased leaves from and the spraying of all tea bushes growing in shady places. Special attention should be paid to tea surrounded by jungle such as nurseries, particularly abandoned ones. Experience has shown that in the plains tea districts the disease is frequently harboured on stray tea plants growing in the jungle. The removal of all such plants from the jungle in the vicinity of infected gardens has repeatedly been accompanied by the disappearance of the blight from the garden concerned within a single year. In Darjeeling the best time to deal with the disease is in the dry season when little succulent leaf is present. The careful removal

of all blistered leaves at that time of the year will prevent infection of the young growth on pruned bushes in the early part of the season. In May or June however new outbreaks frequently occur. These should be treated at once by the removal of diseased leaves followed by spraying with Lime sulphur solution. This treatment should be repeated a week or so later. By prompt treatment of small outbreaks the blight can frequently be held in check until the succulent wood on pruned tea has hardened sufficiently to resist attack. When the weather is favourable to the blight however general infection cannot be prevented in the Darjeeling District.

Læstadia Camelliæ, Cke = ? *Læstadia Theæ*, Rac.

Copper blight.

Refs :—

Shaw, "The Copper blight of Tea. Ag. Jl. Ind." Vol. VI, Part I.

"Indian Tea Association, Scientific Department, Quarterly Journal," 1911. Part III, p. 7.

Butler, "Fungi and Disease in Plants," p. 443.

Petch, "Diseases of the Tea Bush, p. 34.

"Indian Tea Association, Scientific Department, Quarterly Journal," 1921. Part III, p. 168.

History.—In 1884 Cooke described a fungus found on some leaves sent to Kew from Johore. He found two kinds of fructification present and described them separately as two fungi. One of which he named *Sphærella camelliæ* a name which was subsequently changed to *Læstadia camelliæ* and the other *Phoma camelliæ*. The characteristics Cooke described apply to the two forms of the fungus which cause Copper blight in North-East India. Raciborski described a similar disease from Java and named the fungus *Læstadia Theæ*. Although a similar disease of tea had been known in North-East India for some time little

attention was paid to it until 1911. It was then considered to be identical with that described by Raciborski. Subsequently work on the fungus which causes Brown blight shewed that that fungus produced two forms of fructification one of which closely resembled that described as *Læstadia Theæ* by Raciborski. As the latter had noted that *Colletotrichum camelliæ* was present on the same leaves it seemed probable that the fungus he had described was the other form of that fungus. Petch draws attention to this confusion and suggests that the fungus which causes Copper blight is merely another form of that which causes Brown blight. The fungus which causes the disease known as Copper blight in North-East India is however quite distinct from that which causes Brown blight. The two forms of the Copper blight fungus have been reproduced the one from the other in pure culture and successful inoculations of tea leaves have been obtained from both kinds of spores. The two forms of the Copper blight fungus closely resemble the two forms described by Cooke as *Læstadia camelliæ* and *Phoma camelliæ* respectively and the name *Læstadia camelliæ* Cke, has been adopted. Some authorities prefer to use the name *Guignardia* instead of *Læstadia* on the grounds that the latter name had already been used for a species of flowering plants. The name does not matter very much to the practical planter. It is however of great importance to know that the disease known as Copper blight in North-East India is caused by an entirely different fungus from that which causes Brown blight.

Copper blight is found in all the tea districts of North-East India.

Description.—The first appearance of the disease is indicated by the formation of small, yellowish brown patches on the upper surface of the leaf. At this stage the leaf frequently bends over in a peculiar manner, exposing its under surface, which often assumes a coppery sheen. The colour of upper surface of the patches soon changes to a red brown. Later on these patches become larger and often irregular in shape, with a very ill-defined margin. At a later stage they become better defined

and darker in colour extending right through the leaf appearing as a yellowish brown patch on the under surface. As the disease progresses minute dots appear scattered all over the patches. The patches generally appear near the base of the leaf and enlarge and spread usually on both sides of the mid-rib.

When examined with a pocket lens both the surfaces of the diseased patches are seen to be studded with minute black dots, irregularly scattered in the neighbourhood of the veins. These black dots are the openings of round cases in which spores of the kind called pycnospores are produced. A section across such a spot will show under the microscope that the pycnidia are black, more or less spherical receptacles somewhat resembling those of Brown blight in external appearance, but differing in their contents. The pycnidia are produced singly or in groups and remain embedded into the leaf tissue with their mouths opening outside. From the cells of the inner wall of a pycnidium small colourless filaments grow out. These produce colourless one-celled, ovoid spores at their tips. When mature the pycnospores are detached from the cells of the inner wall of the receptacle. When fully ripe the upper portion of the pycnidial wall with its enveloping leaf tissue disintegrates, leaving a small crater-like depression.

This form of fructification is very common and may be found on diseased leaves throughout the year.

At a later stage when the surface of the spot becomes grey and brittle, a second form of fructification appears as minute black dots similar to but smaller than those mentioned above. On examination of a cross section of such a spot, under the microscope, it will be seen that these black dots are crater-like openings of spherical receptacles known as perithecia. The perithecia are black, more or less spherical shape with very short beaks. They are either scattered or in groups and are immersed in the leaf tissue, with their beaks communicating with the outside. They contain a large number of club shaped sacs (asci) each containing 8 spores (in this case called ascospores).

The asci are colourless, cylindrical and club shaped. The ascospores are also colourless, one celled, broad in the middle and slightly tapering at the ends. When young they contain a large number of refractive granules. They are arranged in two rows within the asci.

This form of fructification is less common and is only found for a few months (May to August) in the year and then only with difficulty.

The second form of fructification has been reproduced in pure cultures obtained from the spores of the first mentioned form.

Depredations.—The fungus infects the leaf when it is still young. It is more common during summer and the rains. It is most frequently observed about the time the second flush appears. It is not so common as Brown or Grey blights. The disease rarely causes severe damage.

Remedies.—Copper blight is not usually sufficiently serious to warrant remedial measures. If the attack is severe it is necessary to pluck off all the infected leaves and destroy them. If this plucking be followed immediately by spraying with a fungicidal mixture, *e.g.*, Lime sulphur solution, the infection of the young leaves is prevented. A second plucking is frequently necessary a day or two later but a second application of spray fluid is rarely necessary after the removal of infected leaves which had not developed obvious signs of the disease at the time the first plucking was carried out.

As the disease usually makes its appearance at the end of the first flush, it is generally possible to apply remedial treatment during the dry spell which precedes the heavy rains. When the disease appears in the heavy rains it is very little use applying spray fluids but if the diseased leaves are plucked off and destroyed there is little danger of serious damage being caused. Sometimes in Darjeeling the progress of the disease is very rapid, but when the disease spreads with such rapidity the diseased leaves generally fall off in a day or two and the young flush

comes away uninfected. Experiments have shown that under ordinary circumstances, *e.g.*, light shade and damp atmosphere the fungus mycelium survived the cold weather when in dead material. But solitary pycnospores when exposed to similar conditions could live only for 8 days. Exposure to direct sunshine was fatal to both, the former however survived for a few months while the latter succumbed within a day.

It is desirable therefore to remove at the time of pruning all dead leaves from plots which had been severely attacked by this disease during the previous season even when the disease has apparently disappeared.

Cercospora Theae.

The Shot-Hole Fungus.

Refs.—

Watt and Mann, " The Pests and Blights of the Tea Plant," 2nd ed., p. 391.

Butler, " Fungi and Disease in Plants," p. 455.

Petch, " Diseases of the Tea Bush," p. 36.

History.—This disease was first described in Java and is also known to occur in Ceylon. It is present in all the tea districts of North-East India.

Description.—It causes small reddish brown spots, usually 2—3 m.m. in diameter. The centre of the spot dries up with age, becomes thin and turns white. It then falls out leaving a clean cut, circular, hole resembling a shot hole from which it has got the name of shot hole fungus. The fungus produces minute smoky-brown dots in the centre of the spots. These dots are the fructifications of the fungus, which are clusters of erect filaments bearing long slender spores at their tips.

Depredations.—This fungus occasionally infects the old leaves but it does not cause any appreciable damage to the bush.

Remedies.—No treatment is necessary.

THE INFLUENCE OF MANURING ON SUSCEPTIBILITY OF TEA LEAVES TO BROWN BLIGHT (*GLOMERELLA CINGULATA*) AT BORBHETTA.

By

A. C. Tunstall.

The present season has not been a very favourable one for Borbhetta. The pruned tea came away very well but later the young growth was severely checked by unfavourable weather and Rim blight was very severe on many plots. Other diseases, caused by vegetable parasites such as the Brown blight fungus, were prevented from doing any serious damage by the cold weather spraying with Lime sulphur solution and the bushes recovered from the Rim blight when the weather improved. About the middle of August, five months after the spraying, Brown blight appeared on some of the plots. It was noticed that the blight was more severe on certain plots manured with large dressings of nitrogen.

These plots cover four acres of Burma tea planted in 1920. This area is divided into 80 plots of 90 bushes each. There are no vacancies. There are 16 sets each of 5 plots similarly manured. The obviously infected bushes were counted in each plot on two occasions. The results of the two counts agreed very well and the results of similarly manured plots also agreed.

Percentage of infected bushes.

Total pounds of nitrogen= per acre.	120	90	60	45	30	15	0
No manure.							
30 lbs. potash K_2O per acre 30 lbs. phosphoric acid P_2O_5 per acre and varying amounts of nitrogen applied in one dose at the beginning of the season	33·8	28·6	15·6	15·6	3·6	6·5	5·3

Percentage of infected bushes.—*Continued.*

Total pounds of nitrogen per acre.	120	90	60	45	30	15	0
30 lbs. potash K_2O per acre 30 lbs. phosphoric acid P_2O_5 per acre applied at the beginning of the season ... ... Nitrogen applied at intervals in doses of 15 lbs. per acre	33·0	35·05	10	...	10·4	...	...
Equal amounts of potash, phosphoric acid and nitrogen applied at intervals in doses of 15 lbs. each	30·2	30·5	13·4	...	6·4	...	...
Average	32·3	31·3	13·0	...	7·1	...	...

N. B.—It should be noted that the plots most heavily manured with nitrogen yielded about 80 per cent. more leaf than the manured plots. It should also be noted that the above plots have been receiving the manures annually since 1924 and that this is the first time any noticeable differences in susceptibility to disease has been noticeable.

All the above plots except the check received potash, phosphoric acid and nitrogen. It is therefore impossible to judge the effect of nitrogen alone. The differences between the number of infected bushes on the plots receiving more potash and phosphoric acid and on those receiving less are too small to be significant but there seems to be a tendency for additional potash and phosphoric acid to reduce infection.

At Borbhetta there is another set of experimental plots—the Kharikatia plots planted in 1919 on which the manurial value of potash and phosphoric acid is being tested. The area is divided into 58 plots of 45 bushes each. There are ten sets each each of five plots and two sets each of four plots similarly manured. A certain amount of Brown blight was present on these plots but the attack was so slight that infection was not obvious

except in the case of one set. A different standard of infection had to be chosen for judging the infected bushes on this area. Three observers individually noted the infected bushes. Only those bushes which at least two observers noted were counted as infected ones. The results for similarly manured plots agreed very well although the observers were unbiassed by a knowledge of the manurial treatment.

The following table gives the percentage of infected bushes.

Potassium at the rate of 198 lbs. K_2O per acre.			Phosphorus at the rate of 94⅔ lbs. P_2O_5 per acre.		Calcium at the rate of 112 lbs. CaO per acre.		Percentage of bushes visibly infected.
Potassium chloride.	Potassium sulphate.	Potassium nitrate.	Superphosphate.	Basic slag.	Calcium carbonate.	Calcium sulphate.	
X	0	0	0	0	0	0	25.3%
0	X	0	0	0	0	0	10.2%
0	X	0	0	0	X	0	14.3%
0	X	0	X	0	0	0	12.4%
0	X	0	X	0	X	0	9.7%
0	0	X	0	0	0	0	23.9%
0	0	0	X	0	0	0	2.2%
0	0	0	0	X	0	0	8.4%
0	0	0	X	0	X	0	2.2%
0	0	0	0	0	X	0	10·6%
0	0	0	0	0	0	X	4.4%
0	0	0	0	0	0	0	4.4%

NOTE.—X indicates that the manure in question was applied.

All sets except the Potassium nitrate one received an annual dressing of dried blood (30 lbs. nitrogen per acre) for the last two years.

N. B.—It should be pointed out that most heavily infected set is yielding not less than 25 per cent. more leaf than the least infected area. It should also be noted that these plots have received the above mentioned manures annually since 1922.

From the above figures it appears that under the soil and other conditions at Borbhetta the bushes receiving heavy dressings of potash for a number of years were more susceptible to Brown blight than those receiving heavy dressings of phosphoric acid. A comparison of the yields however was not in favour

of the phosphoric acid. Although the bushes on the plots manured with a combination of potash and nitrogen without phosphoric acid were the most seriously infected at the same time those plots yield more than 25 per cent. more leaf than the least infected set. The plots receiving a heavy dressing of chloride of potash without any phosphoric acid contained a slightly larger number of infected bushes but the degree of infection of the individual bushes were less marked than on those on the potash and nitrogen plots. The yields of the plots receiving heavy dressings of chloride of potash were about the same as those receiving heavy dressings of superphosphate although in the latter case the number of bushes infected was the least in the whole series. This honour was shared with the set which was manured with crushed lime stone and superphosphate which also gives the lowest yield of the whole series—about 30 per cent. less than the potash and nitrogen set.

The presence of the disease has not, up to date, caused any noticeable fall in crop on any plots. The disease is only attacking the banji leaves. These leaves will for the most part be removed in the ordinary course of pruning and the subsequent spraying will check any Brown blight which may still remain on the bushes after pruning.

In the course of investigations on the disease caused by *Thyridaria tarda* (Diplodia) it was found that bushes manured with heavy doses of phosphoric acid were apparently more susceptible to the disease while those receiving manures which stimulated growth were less severely attacked. Owing to the severity of the attacks of this disease on the plots manured with phosphoric acid it was thought desirable to omit this substance from manure mixtures designed for its treatment. It is possible however that none of these substances have any direct influence on the fungus diseases attacking the bush and that the improvement in the bushes is due not to a reduction in susceptibility to attacks of the parasites in question but to the increased vigour of the host plant.

THE INFLUENCE OF PLUCKING ON THE SUSCEPTIBILITY TO COMMON FUNGUS DISEASES OF TEA LEAVES.

By

A. C. Tunstall.

It is well known that hard plucking is frequently followed by attacks of Red rust, Brown blight and Grey blight. In 1922 the percentage of diseased leaves present on the Tocklai plucking plots was estimated. All the prunings from each plot were collected and the leaves were stripped off together with those remaining on the bushes. The total leaves from each plot were weighed. The number of leaves from each plot was estimated by dividing the total weight from each plot by the weight of a known number. The leaves from each plot were then carefully sorted and the numbers infected by Red rust, Brown blight and Grey blight respectively were recorded. The following table gives the results.

	Banjis removed.	Broken back.	Yield 1922 maunds per acre.	Number of leaves.	% of leaves infected by			Total.
					Red rust.	Brown blight.	Grey blight.	
					%	%	%	%
6" of growth left	+	+	12·79	4417	9·81	1·70	·08	11·59
	−	+	10·34	5934	6·50	·87	·05	7·42
	+	−	13·34	5645	7·73	1·08	·07	8·88
6" + first leaf	+	+	9·17	6430	7·29	·72	·07	8·08
	−	+	8·97	7434	5·66	·40	·04	6·10
	+	−	7·76	7262	5·71	·48	·04	6·23
4" + first leaf	+	+	12·80	5817	8·49	·98	·08	9·55
	−	+	9·38	7141	6·85	·69	·05	7·59
	+	−	9·82	6633	7·29	·80	·03	8·12

Note.— + indicates banjis removed and the shoots broken back and

— indicates banjis *not* removed and the shoots *not* broken back in the respective columns.

The results show that the plots which gave the highest yield had fewer leaves remaining on the bushes and the percentage of diseased leaves was generally higher.

The percentage of disease was however insufficient to cause serious loss and the annual pruning and spraying was sufficient to keep the diseases concerned in check.

It is interesting to consider these figures with those in the previous article.

In all three series the plots with the highest yields were more seriously infected by disease. So far the disease has had no apparent influence on the yield.

METHODS FOR CONDUCTING EXPERIMENTS ON FACTORS AFFECTING THE QUALITY OF TEA.

BY

C. J. HARRISON.

The demand in recent years for better quality teas has led to a greater interest in those factors which are known to affect quality, and attempts are continually being made by planters to investigate these factors and to modify and adjust them to suit local conditions. Such attempts involve experiments altering the various conditions in field and factory, the results obtained being compared with the outturn under normal conditions.

There are many pitfalls into which one may easily fall, in conducting such experiments, causing the results not only to be vitiated but in many cases to be productive of directly misleading conclusions.

It is our object here to indicate certain precautions necessary in carrying out experiments, particularly in the factory, on the quality of tea.

The intention of this article is not to discourage experiments in factories, by indicating the difficulties likely to be met with in carrying them out correctly, but rather to encourage such research and to assist in making the results more valuable.

It is hardly to be expected that all the conditions and precautions mentioned in the following pages can be complied with during experiments, though every effort should be made in this direction, and any irregularity in connection with the manufacture during the experiment should be borne in mind when assessing results.

It is hardly necessary to state that there must be constant supervision of the experiment either by the originator, or by some one who is keenly interested in, and understands thoroughly, what is being done. Experiments which are left in

sole charge, even for a time, of the average tea house staff, can never be relied upon, as it is extremely easy for samples to get mixed during the many operations involved in manufacture. Especially is this important during firing, subsequent sorting, bulking and handling.

The second important consideration is that a check experiment employing the normal methods, shall be run parallel with the test experiment, and that the conditions under which these two experiments are made shall not differ from one another except in the particular condition which is being tested. For instance, suppose that the thickness of spread in the fermenting room is under experiment. Sufficient leaf after withering for 2, 3, 4 or more rolls is bulked and divided into the required number of rolls, either as soon as it comes in from the garden or after withering. Each is withered, rolled, fired and sorted in precisely the same way. Each is fermented at different thickness of spread, at roughly the same time, in the same fermenting room and for the same period. The atmospheric conditions during the whole period should be kept constant as far as possible.

Similarly with other experiments, though modifications occasioned by limited machinery, have to be made.

It will be seen from the above illustration, that there are many "variable conditions." The chief of these are :—

(*a*) The material used,—in this case the tea leaf.

(*b*) The machinery and all apparatus connected with manufacture, including withering chungs and racks, fermenting floors, etc.

(*c*) Atmospheric conditions, including temperature, humidity, air supply or draught, light, etc.

(*d*) The distribution of the material, *i.e.*, thickness of spread, compactness depending on pressure in rollers, and fineness of division, or amount of breaking up of the leaf in rolling and sorting.

(*e*) The time taken over the different operations.

The first "variable condition"—the leaf used, is a most important one since the difference in quality of leaf plucked from two different sections, or even from two different bushes, may far outweigh any difference in subsequent treatment, and may result in erroneous conclusions being drawn.

Quality of leaf used.

Leaf for experiment should be plucked from bushes which have had as nearly as possible the same manuring, pruning, plucking, cultivation, shade, etc., and which are as nearly as possible of the same age and *jat,* and growing on a similar type of soil.

When it is possible to obtain such leaf in sufficient quantity, the difficult operation of bulking the leaf before manufacture is less important than when the leaf is somewhat mixed, although even in this case bulking should be carried out to ensure perfectly constant quality of leaf throughout the whole bulk.

The leaf coming in from the garden or from the withering chungs is tipped out onto a tarpaulin sheet, large enough to take the leaf spread about 6 inches—1 foot deep. Three or four boys then take handfuls of leaf from one corner to another and from the middle to the sides and so on. The corners of the sheet are then lifted up and the leaf shaken in a heap to the middle of the tarpaulin. The heap is again flattened out evenly over the tarpaulin. The separate batches of leaf are then taken up. This can be done best by using plucking baskets each holding about ½ md. of leaf. For one roll 10-12 basketfuls are required. These are filled up by taking handfuls of leaf from different parts of the sheet and when the batches of 5-6 maunds are collectlected, they are taken and spread on the withering racks, or to the rolling room as the case may be. Though this procedure seems somewhat absurd from a practical point of view it is our only way of obtaining reasonably similar samples of leaf with which to start the experiment.

It is probably better to bulk the leaf after withering provided the experiment is not in connection with this stage of manufacture. The advantage of bulking after withering is that less

damage is done to the leaf in handling, and any damage done has less harmful effects on the quality of final product.

Furthermore, differences in degree of wither may occur in different parts of the bulk, owing to some of it being spread at the edge of a chung, and some in the middle. These are eliminated by subsequent bulking. This must however be done quickly to avoid overwithering and it is perhaps advisable to remove the leaf a short time before it is fully withered, when dealing with large quantities of leaf.

Machinery.

Passing now to the second condition—the machinery, etc., used for manufacture,—with regard to the withering process the leaf may be spread either on wire racks or on hessian cloth chungs, but, unless the experiment is to compare the two, it is obvious that leaf for both check and test rolls, should all be withered on one or other—either all on hessian chungs, or all on wire racks of the same mesh. It will be found advisable not to use the racks at the sides or directly under the roof of the house, but those towards the middle where withering conditions are roughly the same all over. If an outside position is used, the extreme edges may receive an excess of sun or breeze or rain and be withered to a greater or lesser degree than the leaf on that part of the rack further from the edge.

As regards rolling, it is well known that rollers of different types produce quite different effects on the leaf. A single acting roller is less efficient than a double acting one, working for the same period under the same pressure and with the same number of revolutions per minute. It would also be unsafe to assume that a roller taking 6 mds. would produce exactly the same results as one taking 4 mds.

It is therefore safest to use rollers of the same make, and with tables of the same material, whether granite, brass or wood; similarly, kutcha sifters of the same type, whether rotary or flat, should be used throughout the experiment.

Although little difference has usually has been found to result from the use of cement, glass, or porcelain tiles in the fermenting room, it is always possible to use one type throughout the experiments, so to avoid possible question as to the accuracy of results, this should always be done.

With regard to dryers, considerable difficulty often arises in that one can seldom depend on two dryers, even of the same type, producing the same result on fermented leaf. Firing is such a complicated process that small differences in fan speeds, air baffles, tray speeds, spreader, and operations connected with heating the air, may produce considerable differences in the quality of resulting teas.

For this reason it is probable that the best method is to use the same machine for both check and test rolls. This can only be done when the samples of leaf are due to be taken from the fermenting room at intervals of at least ¼ hour. This will be the case when differences in time of wither, rolling or fermentation are being experimented on. Otherwise, when check and experimental samples have to be fired at the same time, it will be necessary to use different dryers. If however, the experiment is repeated two or three times, using each dryer alternately for check and test rolls, the net result will be a sufficiently reliable one.

One single experiment, even when carried out under ideal conditions, is insufficient evidence on which to base important conclusions, so that the more often an experiment is repeated, the greater becomes the value of its results. Furthermore, experiments should be repeated at different periods of the manufacturing season, since what may be true with regard to high quality June teas, may be untrue for average mid season teas, or autumnals.

Atmospheric Conditions.

The third of the variable factors, namely atmospheric conditions, is one of the most difficult to control throughout the experiment, and it is only by running check and test experiments simul-

taneously, or almost so, that differences due to this factor can be eliminated.

Actual climatic conditions have to be considered in connection with plucking of the leaf, the withering process and fermentation. Midday leaf is not of the same quality as evening leaf plucked from the same, or exactly similar sections, since the latter has been exposed to light and probably sunshine for a much longer period before plucking. The following analyses of leaf taken from the same bushes, at 6 A.M., midday and 6 P.M. on the same day indicate that differences in quality of teas made would occur to a certain extent.

Plucked at	Tannin %	Moisture %
6 A. M.	17·7	78·5
Noon	17·3	75·5
6 P. M.	14·0	74·5

Thus the leaf used throughout an experiment must all have been plucked at about the same time of day.

Climatic conditions, notably temperature and humidity, control withering to a great extent. It is impossible to rely on one day's wither being similar to the next. Thus, unless we can eliminate climatic changes from day to day by repeating an experiment over several days, we must see that the withering of both check and test manufacture, is carried out under the same conditions of temperature and humidity.

In rolling and fermenting, temperature, humidity, and amount of air control the rate of oxidation of the bruised leaf entirely. During the early part of the day, rolling and fermenting rooms are cooler and more humid than later in the day. If one sample is rolled and fermented more than half-an-hour before another, the two cannot be compared with confidence unless there is definite evidence that the temperature, humidity and atmospheric conditions generally have been the same in both cases.

It is necessary in fermenting, that the thickness of spread shall be the same throughout the experiment, since thickness of spread controls the air supply to the fermenting leaf. Similarly in the dryer, fan speeds, size of air inlet, and thickness of spread, each controlling the air supply, must be identical for all sets of samples to be compared, unless the factors mentioned are the ones under experiment.

In the fermenting room again, the question of light, though not of major importance, is worth consideration. Light itself may not appreciably affect fermentation but a spot in direct sunlight will generally be hotter than one in darkness. Rolls of fermenting leaf should therefore be placed roughly equidistant from any source of light.

Thickness of spread. Pressure in roller.

By distribution of the leaf is understood firstly, the thickness of spreading or the area covered by a certain weight of leaf in the leaf house. In withering, a standard thickness of spreading should be one pound of leaf to one square yard. This is a standard which allows of even withering, and though perhaps impracticable on many gardens as a routine practice, should always be employed when experiments are being carried out. In fermenting, a general rule may be made of spreading the leaf the same thickness throughout each experiment; not less than 2½ inches and not thicker than 4 inches, depending on the temperature of the fermenting room. If the spread is thinner than 2½ inches or thicker than 4 inches, uneven fermenting is liable to take place.

A suitable spread of leaf in the ordinary endless chain type of pressure dryer, is obtained by adjusting the spreader to the lowest, or second lowest notch, so that a thin spread is obtained, and uneven drying in different parts of the trays is avoided. With thicker spreading, the air draught is baffled by the successive " blankets " of leaf on the trays, so that a steady air pressure is not maintained over the whole drying area. Where leaf happens to be spread rather more thinly, the air finds a passage through the trays more readily than in other parts, and

the thinner spread leaf is dried more efficiently than the rest. This is avoided by thin spreading universally.

The pressure exerted in rollers is another important factor which requires careful investigation, and so far, little has been done experimentally on this point. Unless the experiments are in connection with pressure, this should be the same for tests and check rolls and it will be found most convenient to employ the method in general practice. This is usually—

No pressure for first roll.
Medium pressure for second roll.
Heavy pressure; five or three minutes up and seven or ten minutes down } for third roll if any.

Marks should be made on convenient places on the rollers, indicating a certain degree of pressure whether hard or medium, and the cap can then be screwed down to the mark, to give the desired pressure.

Chalk marks may be made on one of the threads of the vertical screw so that when the horizontal chain wheel is level with any one of the marks, the required pressure is obtained. These marks should be in the same position for each of the rollers of the same type used.

With regard to the sorting of the finished tea, each sample should be put through the same machinery—sifters and breakers—so that each undergoes the same treatment throughout. It has been found very convenient with small experimental samples to produce only broken grades, by putting rough and fine mal mixed, straight from the dryer through a 3/8 Savage cutter and then through a flat type of sifter, giving the grades B. O. P., B. P., B. P. S., and P. F. If attempt is made to obtain leaf grades, samples will need to be of larger quantity than that obtained from one roll which never exceeds 1—1½ maunds pucca tea.

It is very easy during the many operations in the factory to get various samples mixed up or confused, unless care is taken

to mark each sample throughout manufacture. A useful method is to prepare small lead-foil labels about 4 inches by 2 inches in size, labelled so as to correspond with a separate list of the samples and their respective treatments. The lead labels should be placed with their respective leaf samples in the leaf house, on the rolling table, in the fermenting room and *through* the dryer directly before or after the respective " rolls " of fermented leaf. It will be found convenient to place one or two additional pieces of lead on the dryer trays immediately before and after a " roll " of leaf has gone in, thus avoiding any mixing of " rolls " in the dryer.

Again during sorting, bulking, and sampling, the different samples should be clearly marked.

The last and not least important part of the experiment is the comparison of the samples resulting from the experiment. Samples (roughly two ounces each) should be obtained, after careful bulking, of the rough and fine mal, the cut mal (after going through the Savage cutter), and each of the grades produced. Useful information particularly in connection with withering, is obtained by weighing and working out the percentages of the several grades, and this operation should not be neglected, even though it entails considerable extra trouble.

The small 2 oz. samples should be put in tins, marked clearly on top and bottom of the tin and on a label enclosed with the tea, and sent to a taster for valuation and report.

The marking should be simple and definite enough to prevent confusion. A taster usually does not want to know what the samples actually represent until he has completed his tasting, and prefers the samples marked simply :—

B. O. P. No. 1
B. O. P. No. 2

In sending the samples away, it should be clearly stated exactly what information is required with regard to the characteristics of the teas. A useful form of report to obtain from the taster is one which gives the following information.

Remarks on the liquors, leaf and outturn of rough and fine mals, cut mal, and sorted teas; together with valuations of the sorted teas, and of the cut mal, assuming the latter to be a Broken Pekoe Souchong.

The remarks made on liquors should include comparison between check and test sample of strength, colour, briskness, pungency, body, quality, flavour and creaming down. For leaf one requires a comparison of colour, size, tip (amount and colour of), twist, stalk. On infused leaf the colour, evenness, aroma are required.

Some tasters are able to tabulate the abovementioned characteristics and give marks indicating the degree of each characteristic present in each sample. Such tables have proved of immense value in experiments undertaken by the Scientific Department.

Of recent years it has been the practice of tasters in the big tea concerns, to visit various gardens in the tea districts during part of the manufacturing season. Managers should always be ready to seize any chance of carrying out experiments during the times when a taster is available on the spot, and it will be found that such experiments, carried out with taster and manager present, yield results of great assistance in improving prices and quality.

It is hoped, in a later article, to describe experiments carried out in recent years on the various stages in tea manufacture, and particularly in connection with the withering process.

The Department is always glad to receive particulars of experiments carried out in different factories on the manufacture of tea, and to offer any advice in connection with them.

THE EFFECT OF PHOSPHATIC MANURES ON SOIL ACIDITY.

BY

C. R. HARLER.

In the spring of 1926, extensive trials of phosphatic manures were carried out at Borbhetta. The test crop was mati kalai (*Phaseolus* spp.) and the results were reported in a previous number of this journal (Part IV, 1926). The experiments were carried out on 240 strips of soil and at the end of the year the acidity of each plot was estimated. The results of these estimations are shown below.

The acidity shown by the Hopkins method, the pH value of the soil solution and the pH value of the nitrate of potash extract obtained from the Hopkins acidity estimation were determined. It is necessary first of all to indicate, in general terms, the significance of these three constants.

The Hopkins acidity is estimated by shaking the soil with a solution of potassium nitrate and titrating the acidity thus produced in the solution. With the tea soils of North-East India, the action of the potassium nitrate is, mainly, to substitute some of the aluminium in the soil for potassium, thus bringing into the solution aluminium nitrate, which is acid. If there are plenty of soluble bases, like lime and magnesia in the soil, liberation of aluminium does not take place, and the soil is alkaline.

Soil acidity concerned with aluminium is known as the " mineral " type. Anything which removes the soluble aluminium or other weak bases from the soil reduces the acidity. Lime prevents the aluminium from coming into the soil solution. Phosphates precipitate the aluminium and thus remove it. The addition of potash salts brings aluminium into the soil solution

rendering it liable to removal by leaching. The ultimate result of potash additions is, thus, the reduction of mineral acidity.

The pH value of the soil is a measure not of the *amount* of the acidity present, but of the *strength* of the soil acid. It is possible to reduce the amount of the soil acidity, as indicated by the Hopkins figure, without reducing the pH value. Generally our best tea soils are those which are fairly acid, but, in a few cases, soils showing a low Hopkins acidity have grown excellent tea. These soils have shown a low pH value, *i.e.*, a strongly acid soil solution.

The pH value of the potassium nitrate extract is a figure on which this Department places considerable value. Its significance is not clearly understood and is difficult to explain in non-technical terms. When an acid soil is shaken with nitrate of potash solution, some of the aluminium in the soil minerals (mostly in the clay fraction) is substituted by the potash, and thus enters the solution as aluminium nitrate. This salt gives an acid solution with a pH value of 4.2, because it is composed of a weak base (alumina) and a strong acid (nitric acid). Nitrate of potash is neutral, pH = 7, because it is composed of a strong base and strong acid.*

When the potash attacks the soil constituents it substitutes not only weak bases like aluminium and iron, but also some of the strong bases like lime and magnesia in the form of carbonate. When such substances enter the soil it is equivalent to adding alkalinity, and the acidity is thus reduced and the pH value raised. If, then, the soil solution shows a pH value of 6, for example, and the pH value of the potassium nitrate extract reads much higher than this, say pH = 6.4, then we know

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* Note :—The indication of acidity by the pH scale is at first confusing. Neutrality is indicated by pH = 7. Figures higher than 7 denote increasing alkalinity and figures lower increasing acidity.

Thus—

pH = 4.2 is more acid than pH = 5.4

and pH = 9 is more alkaline (or more non-acid) than pH = 7.5.

that the soil in question has a certain amount of loosely knit lime or alkali in its make up. Such soils almost invariably carry poor tea. If, on the other hand, a soil of, say, pH = 6 shows a pH value of about 5.4 in its nitrate of potash extract, then this soil may be a suitable one for tea, because it carries a reserve of acidity in its clay. If a soil behaving like the last one mentioned still carries poor tea, the reason must be sought in some factor other than soil acidity. Most good tea soils show a pH value of 4.2 for the potash extract, although the value varies from 4 to 4.8.

It now remains to show the effect of phosphatic manures on the acidity of the soil at Borbhetta. It was found that all phosphates which were active in promoting growth of mati kalai had made considerable reductions in the acidity of the soil. This was true of acid superphosphate, showing that the mineral acidity of our soils can be reduced, without the use of lime, by combination with phosphoric acid.

Since acidity varied greatly from place to place on the unmanured soil at Borbhetta, the apparent reductions recorded are not quite regular, but are sufficiently great to be very significant. The results quoted below are the mean reductions in acidity compared in each case with the unmanured check plot alongside.

The first table shows the result of using different manures adding, in each case, sufficient manure to supply 80 lbs. phosphoric acid per acre. Each result recorded is the mean of 6 separate pairs of observations.

The acidity varied all along the line of the plots, and the most accurate method for measuring the effect of different manures was obtained by comparing each plot with the adjacent check plot. These differences were then averaged and are shown below. A negative sign indicates a reduction in Hopkins acidity. In the case of pH values, a positive sign indicates an increase in pH, but a decrease in acidity.

Mean figures for all check plots were as follows:

	Hopkins acidity.	pH of soil.	pH of nitrate of potash extract.
	811	4·21	4·16

Mean change effected by various manures.

	Hopkins acidity.	pH of soil.	pH of nitrate of potash extract.
Basic slag	−283	+·3	+·1
Belgian phosphate	−232	+·3	+·1
Superphosphate	−158	+·2	0
Algerian phosphate	−142	+·2	0
Bone meal	−141	+·1	0
Indophos	− 92	+·1	0
Singhbhum phosphate	− 33	0	0
Plutophos	+ 37	0	0
Radiophos	+ 18	0	0

Changes of 50 or less in an acidity of about 800 have little significance so far as the Hopkins figure is concerned. It will be seen that although superphosphate lowers considerably the Hopkins acidity, it has a relatively small effect on the pH value of the soil.

The second table shows the result of adding increasing quantities of some of the different manures. Each result recorded is the mean of five separate observations.

Mean figures for check plots were as follows.

	Hopkins acidity.	pH of soil.	pH of nitrate of potash extract.
	692	4·80	4.2

Mean changes effected by varying quantities of manures.

Phosphoric acid per acre.	Change in Hopkins acidity.	Change in pH of soil.	Change in pH of nitrate of potash extract.
20 lbs. as Basic slag	− 88	+·5	+·1
40 „ „	− 98	+·2	0
60 „ „	−134	+·4	+·1
80 „ „	−256	+·8	+·2
120 „ „	−360	+·8	+·1
160 „ „	−349	+·7	+·1
40 lbs. as Belgian phosphate ...	− 75	+·4	0
80 „ „ „ ...	−100	+·4	+·1
120 „ „ „ ...	−125	+·5	+·1
160 „ „ „ ...	−173	+·8	+.1
240 „ „ „ ...	−202	+·6	+·1
40 lbs. as Radiophos	−15	+·2	0
80 „ „	−18	0	0
120 „ „	+ 6	+·4	+·1
160 „ „	−47	+·4	0
240 „ „	+19	+·5	0

The figures are not quite consistent but it is clear that both basic slag and Belgian phosphate reduce all forms of acidity significantly and progressively. Radiophos effects no appreciable change in the Hopkins acidity but raises the pH slightly.

Since even acid superphosphate lowers the Hopkins acidity the phosphoric acid in radiophos, if it reacted with the soil at all, would be expected to lower the Hopkins acidity. The failure to alter the Hopkins acidity confirms the results obtained with this manure on mati kalai, showing that this phosphate is inactive in the soil.

Phosphatic manures must be regarded as an important factor in the acidity problem of the tea soils of North-East India.

PROPOSED TOURING PROGRAMME OF THE OFFICERS

OF

THE SCIENTIFIC DEPARTMENT.

Season 1928.

Months.	P. H. Carpenter.	H. R. Cooper.	C. R. Harler.
January ...	Dooars	.....	Dooars
February ...	Board of Agriculture	Doom Dooma & Margherita	Jhanzie
March ...	Calcutta ...	.....	Moran
April ...	Nahorkatia & Tingri	Nowgong & Kamrup	.....
May ...	Bishnath & Boroi ...	.....	Orang & Tezpur
June ...	Calcutta ...	Happy Valley ...	.....
July ...	Juri, Doloi, Lungla ...	.....	Panitola & Dibrugarh
August ...	South India ..	Dooars	.....
September ...	.....	Terai & Darjeeling ...	.....
October ...	Calcutta ...	.....	Longai & Chargola
November ...	.....	.....	.....
December ...	.....	.....	.....

Mr. Andrews and Mr. Benton will tour as the investigations which they are making will necessitate. Mr. Tunstall and Mr. Harrison will be on Home Leave.

The exact date on which the above tours take place will be given later to the respective sub-district Chairmen. Managers desiring a visit from the scientific officer must inform the sub-district Chairman who will make out an itinerary for the touring officer.